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Forthcoming Events.

APRIL 22-23.

The Faraday Society:—General discussion at Oxford on "The Theory of Strong Electrolytes."

APRIL 25.

Royal Society of Arts:—Cantor Lecture No. I, in London. "The Measurement of Light," by John W. T. Walsh, M.A., M.Sc.

Society of Chemical Industry (Chemical Engineering Group):—Additional meeting in London. "Permanent Moulding Machines for Cast Iron," Paper by Professor J. W. Hinchley, Wh.Sc., A.R.S.M., F.I.C.

APRIL 28.

Institute of Metals (London Local Section):—Annual general meeting. Open discussion on "The Working of Metals," opened by E. I. Thorne.

APRIL 29.

Diesel Engine Users' Association:—Ordinary meeting in London. "Further Developments in Mechanical Injection Oil Engines," Paper by Oswald Wans.

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCIATION.

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Secretary: K. S. Bridges, Avenue Chambers, Southampton Row, London, W.C.1.

Hall-marks for Cast Iron.

To most people outside the industry, including many users, cast iron is just cast iron, and differences in quality and grade are not understood. One of the most telling signs of the times in the foundry world, however, is the outcrop of irons possessing or said to possess special characteristics, in consequence of which they are given proprietary names. This practice of branding or labelling cast products is scarcely to be commended, and in some ways it appears to be foreign to the British habit of mind, since British irons similar to some extensively advertised specialities of foreign origin remain unbaptised. In any case, a little clear thinking would enable the industry to temper the adoption of such labels with logic.

We think it will be generally agreed that cast iron itself ought not to be specifically labelled with a proprietary name, apart from any trade-mark or designation which might apply to it as a product, part of a product, or part of a class of products made by a particular firm. Thus pig-iron brandmarks are of very great commercial importance as marks of quality, but do not in the main imply any particular method of production. It seems in the case of cast iron a sound principle to allow the metal to be graded according to a required specification, such for example as a B.E.S.A. specification. This implies particular properties, but not a particular method of production, and a manufacturer in meeting such a specification is free to employ whatever process suits him best. If a process gives special properties he may naturally be compelled to adopt it in meeting specifications embodying these properties.

On the other hand it appears to us perfectly legitimate to apply proprietary names to processes which have novel features. Successful processes are often followed by a crop of other named processes aiming at similar results by a different method, but this, although confusing, is not, of course, to be deplored. If the Blank process is introduced for making cast iron we admit that there is a very strong temptation, in the shorthand of everyday speech, to refer to the product as Blank's iron, whereas in its true designation one should refer to iron by Blank's process. The difficulty is seen more clearly when it is remembered that Dash may devise a cupola modification and refer to the Dash cupola. The temptation here is to refer to the iron produced in this cupola as Dash iron, since it is made by the Dash cupola, in spite of the fact that half-a-dozen rival cupolas may be producing material of similar properties, or that indeed the process may be producing ordinary iron but on more economical lines than usual.

We doubt whether the average foundryman is aware of the extent of these developments. In a report issued by the Cast Iron Research Association, we understand that no less than ten of these "named varieties," to borrow a horticultural term, are referred to, and the process having gone so far seems likely to continue.

We have suggested that in the case of novel developments the process and not the product should be labelled, and we suggest further that the classification of the quality of the product in terms of clearly defined and preferably national specifications, should considerably lessen the bewilderment with which the ordinary founder is at present liable to be assailed.

Southport Corporation and the Foundry Industry.

The Southport Corporation have never shown much sympathy with the foundry industry, although possibly they are always very desirous to obtain its members as holiday visitors; some few years ago they declined officially to receive the Institute of British Foundrymen when it was proposed to hold an annual conference at Southport, but the latest blow they have dealt to the trade will create widespread indignation against Southport and its rulers. It is well known, from the various Papers read before the Institute upon "Oil Sand Cores," that the Southport sand is one of the best to use; this sand is in super-abundance, and has been collected by local carters for many years without let or hindrance, and has been a fine advertisement for the town, but some astute official had a sudden brain-wave in that as this sand was of such benefit to foundries it ought to be of financial benefit to the Corporation. During periods of storm so great is the influx of sand that the Corporation have to pay carters to clear it away, but the first official move is made by giving 24 hours' notice only prohibiting the removal of any sand of any nature, the excuse given being that the Corporation intend, at some future time, to build an esplanade in some outside part of the town and will require all the sand. The absurdity of the excuse did not dawn upon the official mind, neither did the disastrous result of the sudden stoppage of supplies caused to foundries. This created a crisis among several works, particularly in the Midlands and Lancashire, where four or five foundries had to stop work for a week, and others had to delay all core making. Strong representations were made to the Southport Corporation as to the National necessity for supplies to be obtained when the official mind at length moved, and it was decided to allow sand to be collected from such parts of the coast, as officially decreed, whether suitable or not, and that a royalty of 1s. per ton be paid to the Corporation. This charge increases the cost of the sand by 50 per cent., and as some foundries use large quantities, the Southport Corporation have added a further unnecessary cost to the production of castings. The general indignation among Lancashire and Yorkshire foundries which has been caused by this action cannot be a good advertisement to Southport so far as foundrymen are concerned.

The Refractories Association of Great Britain.

There was a large and representative gathering of members of the Refractories Association of Great Britain at the Royal Victoria Hotel, Sheffield, on April 8, to hear Mr. H. Halliday (Chairman of the Employers' National Council for the Clay Industries, and a Vice-President of the Association), who gave an interesting and instructive talk on the subject of "Railway Rates."

In the absence of the President (Mr. Job Holland), the chair was taken by Mr. Titus Searson (past-President).

Mr. Halliday gave a concise *résumé* of the whole question, and commencing with the position in which the railway companies found themselves after the war, he gave a detailed account of the negotiations undertaken on behalf of the whole trading community by the Traders' Co-ordinating Committee, and made special reference to that part of the negotiations in which the E.N.C.C.I. had co-operated with the Refractories Association for the protection and assistance of all traders in the clay and refractories industries. He then explained the probable effect of the changes which will come into operation when the "appointed day" for the new classification of goods was definitely fixed, and outlined the steps which should be taken by all traders for the retention of any exceptional rates which they are at present enjoying.

The evening concluded with a very hearty vote of thanks to Mr. Halliday for his most instructive address, proposed by Mr. T. Searson and seconded by Mr. Thornton.

New British Chemical Standard Cast Iron "D2."

The organisers of the British Chemical Standard movement inform us that they now have ready a grey phosphoric cast iron in the form of very fine turnings, and having the following standardised composition:—

Silicon	.....	1.31 per cent.
Phosphorus	.....	1.07 per cent.
Manganese	.....	1.64 per cent.

The approximate composition of the elements are graphitic carbon, 2.5 per cent.; combined carbon, 0.8 per cent.; sulphur, 0.03 per cent.

This iron takes the place of iron "D" as regards phosphorus content, but also fulfils the need for a low silicon iron and a high manganese pig-iron standard. Used in conjunction with hematite iron "A" this covers the range of most irons met with by the foundry chemist. As usual it is packed in bottles containing 500, 100 and 50 grms. of fine turnings free from dust, and may be obtained either from organising headquarters or most laboratory furnishers at a price which is estimated as sufficient to cover the cost.

The German Foundrymen's Technical Association.

The seventeenth annual meeting of the Verein Deutscher Giessereifachleute E.V. will be held from May 6 to May 8 in Berlin under the chairmanship of Dr. Ing. E.h. Dahl.

The registration will take place at the offices of the Association, Friedrichstrasse 100 (near to the Friedrichstrasse Station), whilst the first technical session will be held at the large hall of the Verein Deutscher Ingenieure, Friedrich-Ebertstrasse 27.

The following Papers are expected to be presented:—

(1) "A New Moulding Sand Testing Process," by Reichsbahnrat Dipl. Ing. W. Reitmeister.

(2) "The Wearing Away of Cast Irons, their Renovation and Mechanical Properties," by Dr. Ing. Kühnel.

(3) "The Relationship of the Raw Materials of the Foundry, Especially in Regard to those for the Production of Cast Iron," by Beratender Ing. Joh Mehrtens.

The second technical session, held at 10.30 on the Sunday morning, will be held in the Banqueting Hall of the Zoological Gardens, and on this occasion the following Papers are to be submitted:—

(4) "The Cupola in Theory and Practice during Recent Decades," by Geh. Reg.-Rat. Prof. Dr. Ing. Mathesius.

(5) "The Relationship Between Shape and Mechanical Properties of Metals, in the As-Cast Condition," by Dr. Ing. W. Claus.

(6) "Combustion Conditions in the Cupola, and How They Can be Influenced by the Introduction of Powdered Fuel," by Dr. Ing. F. Bardenheuer.

Foundry Query.

Hydraulic Jiggers.

We have been asked to supply some hydraulic jiggers to work at a pressure of 250 lbs. per sq. in., and to be worked by sea water. Can you please tell us the most satisfactory metal which can be used for this purpose?

C. D. V.

Catalogue Received.

Sand Plant.—Messrs. Penney and Porter (Engineers), Limited, of Broadgate, Lincoln, have prepared a 4-page leaflet illustrating and describing Hall's Improved Invincible Sand Mixer. It is representative of the type in which the sands to be mixed are fed into a hopper communicating with a cylindrical chamber in which sets of bars rapidly revolve in opposite directions.

A second machine—a rotary screen—is described on a second leaflet, which can alternatively be hand or power driven.

Blast Furnace Practice at Consett Iron Co., Ltd.*

By C. S. Gill (Blast Furnace Manager).

When the arrangements were made for a visit of the Newcastle Branch of the Institute of British Foundrymen over the above works, a suggestion was made that after the members had seen the plant in operation it would be appreciated if a Paper could be read describing the plant, and giving an insight into the working of a blast furnace in an elementary manner. It will therefore be realised that this Paper is not in any way meant to be a treatise on modern blast furnace practice, but is merely an account of conditions prevailing on the plant under discussion, together with a rough outline of the theoretical side of blast furnace operation and a description of the pig-iron produced by this company.

Description of Plant.

There are eight blast furnaces, seven of which date from 1873 to 1880, and are small furnaces as compared with modern practice, being only 55 ft. high and having a hearth diameter of 10 ft., but in spite of their age and size, the furnaces give remarkably satisfactory results in operation, and it is no uncommon thing for a furnace to make 1,100 to 1,200 tons of iron in a week.

There is also one modern furnace 75 ft. high and 12 ft. 6 ins. hearth diameter, which is capable of making up to 2,500 tons of pig-iron per week without the addition of scrap to the charge, and it will be observed that a system of cooling blocks is built into the walls of the bosh and well of this furnace to preserve the brickwork.

The small furnaces are blown from a common main, the blast being heated by stoves of Cowper design (three stoves to each furnace) capable of heating the blast to a temperature of 1,500 to 1,600 deg. F., each stove having a heating surface of approximately 36,000 sq. ft.

After leaving the stove the blast is conveyed through the horseshoe main or bustle pipe to the tuyeres, of which there are nine to each furnace, evenly spaced round the well at a height of about 5 ft. 6 in. from the hearth to centre line of tuyere, and enters the furnace at a pressure of, roughly, 5 lbs. per square inch.

The coil tuyeres used at the small furnaces have an internal diameter of 5 in. at the nose and are cast in the Consett foundry.

A range of 29 water-tube boilers provides the steam for the turbo blowers and electricity generators, the boilers being fired with blast-furnace gas. The turbo blowers are five in number, and the particulars of their size and capacity are as follows:—

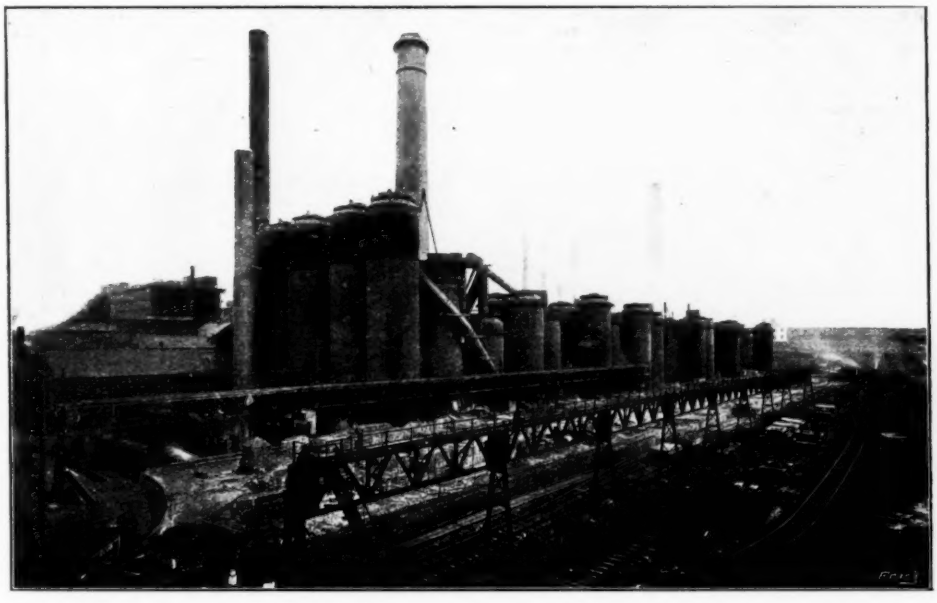
Two turbos approximately 26,500 cub. ft. at 5 lbs. pressure.

One turbo approximately 30,000 cub. ft. at 5 lbs. pressure, or 28,000 cub. ft. at 10 lbs. pressure.

Two turbos approximately 40,000 cub. ft. at 15 lbs. pressure.

The furnaces are handcharged, the materials being loaded into barrows and hoisted to the top of the furnace on inclined lifts.

No. 8 furnace is blown isolated, and is provided with four stoves capable of heating the blast to 1,400 to 1,500 deg. F., and having a heating surface of 75,000 sq. ft. per stove, and in her case the blast is passed through ten 5-in. copper tuyeres which, as in the small furnaces, project 9 in. into the well. She is blown by volume, and the blast supplied is in the neighbourhood of 35 to 37,000 cub. ft. per minute at a pressure of about 14 to 15 lbs. per sq. in. This furnace is charged similarly to the small furnaces.



The Blast Furnace Plant, Consett Iron Company, Limited.

The bell and hopper system of lowering the material into the furnaces is used, and the bell is operated by compressed air.

The pig-iron produced is all sand cast on the pig beds in combs weighing approximately 2¼ tons each, and these are lifted from the beds and put upon comb bogies, which transfer the iron to the pig breaker, where it is broken into half-pigs straight into trucks ready for distribution. At the end of the cast, when the furnace is dry, the tap hole is stopped with fireclay by a mud gun operated by compressed air.

Materials Used.

Iron Ore.—The ores used at the Consett plant are all imported, the bulk of them being from the company's own properties in the Bilbao district of Spain. In practically every case the iron exists as hydrated ferric oxide ($2Fe_2O_3 3H_2O$) and the following is a representative analysis of the "Rubio" ore received from Spain:—

	Per Cent.
Iron (Fe)	48.75
Silica (SiO_2)	8 56
Sulphur (S)	0.029
Lime (CaO)	0.50
Phos. acid (P_2O_5)	0.036
Manganese (Mn)	0.69
Moisture (H_2O)	9.38

* A Paper read before the Newcastle Branch of the Institute of British Foundrymen during a visit to the Consett Works. The Author is their Blast Furnace Manager.

It will be observed that the iron present only forms 48.75 per cent. of the total of the ore, and the function of the blast furnace is to extract the iron from the other material and to lift it to a temperature at which it will flow from the furnace. To do this two other materials are essential, namely, coke and limestone, together with the necessary oxygen supplied by the blast and projected through the tuyeres at high pressure.

Coke.—The coke used is from two of the company's own coke-ovens plants, one being the ordinary by-product coke made in 20½ in. ovens, average width, and the other being a high-temperature coke produced in their Fell coke works, where the ovens are comparatively narrow, *i.e.*, of 17¾ in. average width, and have walls built of silica bricks. An approximate analysis of the coke is as follows:—

Fixed carbon	84.45
Vol. hydrocarbons	3.42
Sulphur	0.70
Ash	8.93
Moisture	3.20
	100.70

The value of the coke for the blast furnace depends, from the chemical standpoint, on the percentage of available carbon present. The ash in the coke itself has to pass from the furnace as slag and a definite proportion of the carbon present is required to deal with this slag from the coke itself. The residue of carbon is available for the operations proper of the blast furnace, and it is upon this figure that the value of the coke depends.

Limestone.—The silicious matter of the ore and the ash of the coke are both acid in character and require the addition of a base to form fluid slag. The composition of the slag has a vital bearing upon the operation of the furnace and the quality of the pig-iron produced. The amount of limestone charged is arrived at by careful calculation of the siliceous matter going into the furnace in view of the analysis of the slag which is desired, this latter varying with the type of iron which it is desired to produce. An analysis of limestone from the firm's own quarries is as follows:—

	Per Cent.
Calcium carbonate ...	92.62
Silica	2.63
Ferric oxide and alumina ...	1.08
Magnesium carbonate ...	3.09
Sulphur	0.098
Phosphorus	0.016
Moisture	0.54
Lime	51.86

Reactions in the Furnace.

The ore, coke and limestone are continuously charged into the top of the blast furnace, the level of the stock being maintained at 10 ft. to 12 ft. below the charging platform; it there meets a current of rising gas, ascending at a high velocity. The gas is of a strongly reducing character, and leaves the furnace at a temperature varying between 300 and 800 deg. F., depending upon the conditions prevailing at that time in the furnace. The effect of this hot gas on the moist material is practically instantaneous, first of all in commencing to drive off the moisture present and raise the temperature of the material, and secondly to extract the oxygen from the iron oxide.

Under normal conditions the moisture present is probably all removed in a comparatively short time, whilst the reduction of the iron oxide also proceeds continuously, being completed with ores of this type, comparatively high up in the furnace. As the temperature rises, the carbon dioxide (CO_2) in the limestone is also driven off, and there descends down towards the bosh of the furnace a column of material rapidly rising in temperature and consisting of coke, lime, and the ore in which the iron is in a spongy condition, mixed with the gangue and slag matter.

At the bosh where the temperature is in the neighbourhood of, say, 2,000 to 2,200 deg. F. melting begins, and the molten material commences to drip down through the coke into the hearth; here it separates into two layers, the metallic layer falling to the bottom and the slag floating on the surface. This means that each drop of iron as it melts and falls through the coke is compelled to pass through the slag before reaching its own level, and from this it will be seen how important the composition of the slag is, as it acts as a purifying agent upon the iron.

The composition of the slag has another important bearing in the furnace, as slags of different analyses have widely differing melting temperatures, and this melting and free-running temperature of the slag is a governing factor in the heat of the hearth of the furnace, *i.e.*, a silicious slag has a low, free-running temperature, and the iron produced with such a slag will be a "cold" iron, low in silicon and high in sulphur. Conversely, a "limy" slag with a high melting point and free-running temperature leads to a "hot" iron, high in silicon and low in sulphur.

Needless to say, these are generalisations, and one must ever bear in mind that in the blast furnace there are numerous reactions taking place, many of which are directly opposed to each other, and some small change in local conditions will so alter the flow of the reactions as to produce at times a startling change in the results obtained.

Two analyses of blast-furnace gas are given below, the first being a gas coming from an economically-worked furnace, and the second from a furnace in which not quite such good economy is being effected.

	a. Per cent.	*b.* Per cent.
Carbon monoxide (CO)	25	31
Carbon dioxide (CO_2)	14	10
Hydrogen (H)	2	2
Nitrogen (N)	59	57

Whilst the materials are being subjected to the high temperature of the hearth, namely, about 2,900 to 3,300 deg. F., a certain amount of reduction of minerals other than iron takes place, *e.g.*, a proportion of silicon (Si) is reduced from the silica (SiO_2) present, according to the equation $SiO_2 + 2C = Si + 2CO$, and the manganese is similarly reduced; both these reactions absorb heat and can only take place when sufficient heat is available. From this it follows that the amount of silicon which passes into the pig-iron is usually in proportion to the heat of the hearth, a hot furnace giving a high silicon iron, a cold furnace giving a low silicon iron.

With regard to phosphorus, practically all the phosphorus present in the materials charged into the furnace passes into the pig-iron, and from this it will be seen that for the production of low phosphorus iron it is essential that low phosphorus ores, etc., be employed.

Sulphur is present in the charge, as shown by the analyses which have been given, and a proportion of this invariably passes into the pig-iron; it has, however, an affinity for the lime of the slag, and if the heat of the furnace is kept up, the vast majority of the sulphur is carried away by the slag and the percentage found in the iron is very small.

There is one other element found in pig-iron, and this is the vitally important substance carbon. In the upper part of the furnace shaft a reaction takes place in which carbon dioxide is decomposed in the presence of the freshly reduced iron with the formation of carbon monoxide and free carbon. This carbon is deposited in the form of a very fine powder in the pores and upon the surface of the ore. When the iron sponge melts it is in immediate contact with this carbon besides the carbon of the coke, and it absorbs it to the extent of approximately 3 to 4½ per cent. Iron produced under the Consett conditions usually contains between 3½ and 4¼ per cent. carbon, and this varies very little even with irons of greatly differing grades, although the tendency is for the low grades, *i.e.*, irons made in a cold furnace, to contain less total carbon than those made in a hot furnace.

Materials Produced.

The four main products from the blast furnaces here are (*a*) hematite pig-iron, (*b*) low phosphorus foundry pig-iron, (*c*) slag, and (*d*) gas.

Of these the slag is treated as a waste product; the denser varieties have use for road-repairing, and the limy slags could be made into slag cement, but so far the Company has not seen its way to incur the rather high expense of installing a slag cement plant. An average analysis of the slag produced at Consett is as follows: CaO, 48.0; SiO_2, 32.0; S, 2.0; Al_2O_3, 11.0; MgO, 5.0; and Mn, 1.0 per cent.

An analysis of the gas has already been given in this Paper. Practically the whole of it is used, first for heating the stoves, and secondly for combustion in the boilers for the generation of steam to drive the turbo blowers and generators.

Hematite Pig-Iron.—Owing to the purity of the ores on its properties in Spain, the Company is in a fortunate position for the manufacturing of hematite pig-iron of high quality, and during the last seven years this iron has become deservedly popular amongst those steel workers and foundrymen who require an iron of consistent and reliable analysis. No pains are spared to give foundries the exact iron which is most suitable for their particular requirements, and in their stock heap the Consett Company have had more than 80 different stocks, each different from all the others in some element, from which they have been able to supply pig-iron according to the foundry's own specifications.

All types of hematite iron are made, special low silicon iron which also runs low in sulphur, medium silicon iron running 2 to 3 per cent., and higher silicon irons running 3 to 4 per cent. and 4 to 5 per cent. are made as the consumer demands. The percentage of manganese ranges from 1 per cent. maximum for certain foundries and up to 2 per cent. minimum for others.

The approximate analyses of the varying grades of hematite iron are outlined below, but of course these are varied widely to suit the various users' requirements.

	No. 1	No. 2	No. 3	No. 4	No. 5	Mtld.
	%	%	%	%	%	%
Graphitic carbon ..	3.70	3.65	3.45	3.10	2.75	1.90
Combined carbon ..	0.35	0.40	0.50	0.75	1.00	1.60
Silicon ..	2.50	2.00	1.75	1.50	1.00	0.80
Sulphur ..	0.025	0.04	0.06	0.09	0.12	0.20
Manganese ..	1.25	1.20	1.00	0.90	0.80	0.70
Phosphorus	0.06	0.06	0.06	0.06	0.03	0.05

Low Phosphorus Foundry Iron.—More recently the Company has carried out the manufacture of low phosphorus foundry iron similar to Scotch iron in analysis. This material has been very favourably received, and the demand is increasing, with the result that its production has now become a regular feature of its operations. This iron is made chiefly from hematite ores to which an addition of the necessary phosphorus is made, and this factor seems to give the iron the good qualities of both hematite and Scotch. Generally this is supplied in two main grades, and the analyses of these are:—

	No. 1.	No. 3.
Silicon	2.0 to 4.0%	3.0% max.
Sulphur	0.04% max.	0.06% max.
Phosphorus ..	0.5 to 0.8%	0.5 to 0.8%
Manganese	1.0% approx.	1.0% approx.

From each cast of iron two samples are taken, with occasionally three samples if circumstances warrant, and these samples are analysed separately before the iron is broken at the breaker. With these analyses before him the weighman decides on the destination of each truck load of iron, and it is no uncommon thing to dispatch well over 5,000 tons of pig-iron of varying grades in a week.

A foundry manager has kindly furnished the following figures as representing practice with a 48-in. cupola, and suggested that a comparison with the corresponding figures for the Consett blast furnace practice might be interesting. The author takes this opportunity of thanking him and, acting on his suggestion, presents two columns which supply the comparative information.

	Cupola.	Blast Furnace.
(*a*) Molten iron produced per hour	7 tons.	13½ tons.
(*b*) Weight per charge ..	Pig, 20 cwts. Coke, 2 cwts. Flux, ½ cwt.	Ore, 123 cwts. Coke, 56 cwts, Flux, 26 cwts. (varies).
(*c*) Ratio tuyere area to cross section area of hearth	1 : 6	1 : 90
(*d*) Blast pressure.. ..	10–14 ozs.	13–15 lbs. per sq. in.
(*e*) Air per minute ..	3,700 cub.ft.	35/37,500 cub. ft. per min.
(*f*) Temp. in melting zone	15/1600 deg. C.	16/1800 deg.C.
(*g*) Temp. of ingoing blast	40 deg. C.	7/800 deg. C.
(*h*) Temp. of gas at throat	—	2/400 deg. C.

The Influence of Constituents on Pig-Iron.

Until a few years ago pig-iron was graded and sold to fracture only. The most open or coarse-grained was termed No. 1, and as the fracture got closer the number was correspondingly increased. It was known that the rate of cooling had an influence on the fracture, and care was taken not to chill the pig too quickly after cast. Numerous analyses showed that this grading was due in a general way to the presence of silicon and absence of sulphur, and although the grading system is still used it is becoming general practice to include a chemical specification when purchasing pig-iron. Other elements in the pig besides silicon and sulphur influence the fracture, and it is proposed to deal with all the common elements individually to enable us to follow their influence.

Carbon.—The chief element is carbon. It exists in the metal in at least four distinct forms, though it will answer the purpose if attention is confined to the graphitic and combined forms only.

All the carbon is in solution when the melt is tapped from the furnace, but as the mass cools a proportion crystallises out in the form of flakes or powder of graphite, giving the metal a greyish-black crystalline appearance, most marked in the fracture of high grade iron. Grey iron contains from 3½ to 3¾ per cent. graphite, and when it is considered that the density of graphite is only two-sevenths that of iron it will be seen that 12 per cent. of the volume of pig-iron is made up of these flakes. The flakes are composed of nearly pure carbon, and owing to their brittleness and to the fact that they show decided cleavage planes they greatly reduce the strength of the iron.

Combined carbon is that part of the total carbon which remains in the matrix alloyed with iron. Its presence exerts great influence upon the physical properties of the metal as well as on the fracture. When the combined carbon is low, say 0.3 per cent. (No. 1 iron), the metal is soft, and as the combined carbon rises the hardness increases until at the other end of the scale, say 3½ per cent. combined carbon (white iron), the metal is extremely hard, though brittle, and its strength in tension and even in compression is greatly reduced.

Silicon.—There is a wide range in the silicon content of pig-iron. In white iron the silicon will sometimes run as low as 0.35 per cent., and in grey iron up to 5.0 per cent. In the coke furnace it is not economically possible to make a product with less than 0.35 per cent. silicon, as the sulphur usually runs up to prohibitive limits. The production of very high silicon iron necessitates an extremely hot furnace, with the result that the cost of production is considerably increased owing to the excessive coke consumption and reduction in output. The effect of silicon is to throw the carbon out of solution into the graphitic form; thus it follows the higher the silicon the more open the fracture. Silicon itself has little effect upon the strength of the metal except indirectly, as owing to its influence on the carbon it causes the metal to be soft and also reduces its strength.

Sulphur is probably the most objectionable element in the metal. For this reason specifications usually demand a low limit. In the coke furnace it is not usual to make pig-iron containing much less than 0.025 per cent. sulphur, and even this figure necessitates the furnace being driven on a light limy burden, so increasing the

cost. When the pig is re-melted in the cupola this element is correspondingly increased according to the sulphur content of the coke used, and when an exceptionally low sulphur is required in the casting it might prove advantageous to pay greater attention to the selection of the coke than to demand an iron with an exceptionally low sulphur content. Sulphur exists in the pig as sulphide of manganese or iron. Owing to the low melting point of iron sulphide it tends to find its way to that portion of the metal which is the last to solidify, thus causing shrinkage. Sulphur appears to change the carbon from the graphitic to the combined form, and in this way hardens the iron as well as closing the fracture.

Phosphorus is an element over which the blast furnace management have no control in the blast furnace. Phosphorus combines with iron to form one or more definite compounds which have low melting points. These constituents dissolve in the iron, lowering the melting point of the matrix and causing the metal to be more fluid. This fact is made use of when fine, thin castings have to be made and the phosphorus content is run up to 1¼ per cent., though where strength is the predominant factor an iron containing ½ to ¾ per cent. is to be preferred. Phosphorus does not appreciably affect the hardness, though owing to its tendency to eliminate blowholes, it promotes soundness; it also decreases shrinkage.

Manganese.—Up to about 1.0 per cent. manganese is beneficial to cast iron, but as the percentage increases its good effect undergoes a reversal. Manganese greatly neutralises the effect of sulphur. This is due to the fact that it has a greater affinity for sulphur than has iron. It is a general law of metallurgy that a metal will dissolve compounds of itself much more freely than compounds of another metal, therefore it follows that when the sulphur is taken up by the manganese the manganese sulphide tends to float on the surface of the matrix and separate itself, thus eliminating a part of the sulphur in the casting. It must also be pointed out that this element tends to prevent the absorption of sulphur from the fuel during re-melting in the cupola. Manganese, owing to its removal of the sulphur, tends to soften the iron, but it also tends to hold the carbon in the combined state and so hardens the metal, and as a general rule it can be taken that any increase above, say, 1 per cent. manganese, has a hardening tendency.

Table I summarises the effects of the constituents upon cast iron :—

	Si.	Mn.	P.	S.
Total C ..	Decreases	Increases	Decreases	Neutral
Graphite	Increases	Decreases	Neutral	Decreases
Comb. C...	Decreases	Increases	Neutral	Increases
Soundness	Promotes	Promotes	Promotes	Decreases
Strength ..	Decreases	Decreases	Decreases	Decreases
Shrinkage	Decreases	Increases	Neutral	Increases
Chill ..	Decreases	Increases	Neutral	Increases
Hardness..	Decreases	Increases	Neutral	Increases
Fluidity ..	Decreases	Neutral	Increases	Neutral
Sulphur ..	Excludes	Excludes	Neutral	—

Foundry Statistics.

During January the U.S. pig-iron exports totalled 3,734 tons, as against 1,663 in January, 1926. Their imports of pig-iron during this month were only 9,326 tons, as against 48,423 in January, 1926. Iron and steel castings exported by U.S. during January both showed slight increases over the previous year, being 770 and 421 tons respectively. Cast-iron pipe imports jumped from 2,005 to 9.534 tons in the months being compared.

The Belgium-Luxemburg Customs Union report that during 1926 they imported 330,050 tons of pig-iron, of which 34,941 tons came from Great Britain. They exported 85,078 tons to Britain, out of a total amount of 157,247 tons. They bought from us 150 tons of castings, but sold us 7,954 tons, whilst 10,467 went to the United States. Their total export of castings was 44,074 tons.

During February Germany produced 966,909 metric tons of pig-iron against 631,374 in 1926. This figure included 87,752 tons of foundry iron.

London Foundrymen Visit Birmingham Foundries.

Last Tuesday week an important delegation of London foundrymen attached to the Institute of British Foundrymen were the guests of the Birmingham Aluminium Company, Limited, and its associated firm, the Midlands Motor Cylinder Company, Limited. During the morning the guests inspected the north foundry, a comparatively new installation entirely devoted to the production of grey-iron automobile castings. About 10 tons of metal per day is melted. The shop is higher than the average cylinder foundry, and overhead cranes eliminate very largely the necessity for conveyors, but it is proposed to increase both the length and capacity of the shop, which will be revolutionary in character, and render the shop unique in the layout of this category of foundries.

At a luncheon offered by the firm, Mr. R. J. Shaw expressed the indebtedness of the London Branch to the group of firms for the courtesy in throwing open their shops for inspection and for their hospitality.

Mr. V. C. Faulkner said how much the foundry trade appreciated their host's (Mr. Percy Pritchard's) work in placing before the automobile industry the exact position in which it stood in relationship to the foundry trade. He congratulated the company on the enterprise they always showed. He believed that the group of foundries operated by their host were the largest automobile foundries in Europe, whilst certainly the Birmingham Aluminium Company was the largest foundry handling that metal in this country.

Mr. Pritchard, on behalf of his co-directors, said how he was deeply appreciative of the compliments paid to himself and company with which he was associated. Whilst they were undoubtedly one of the largest concerns engaged upon motor cylinder manufacture, he attached more importance to the quality of the castings manufactured. The visitors would see for themselves the control that they had instituted for eliminating and providing for variations in the quality of the raw materials they used. He drew attention to the sand-preparing plant, which allowed them to utilise a much lower percentage of new sand in their facing mixtures, which obviously brought about very large economies both in the purchasing of new materials and the disposal of waste sand.

When the new North Foundry was completed, he would be pleased for them to re-visit that department.

The afternoon was devoted to an inspection of both the die and sand castings departments of the aluminium foundries, where thousands of castings of an average weight of only a pound were turned out daily. The laboratories and testing department are of a very high order, and are splendidly equipped. The last section to be inspected was the original cylinder foundries. The sand-preparing plant created much interest. Conveyors raise the sand from the dump in the foundry, and pass it through a rotating sieve, where the iron content is magnetically separated. After thoroughly reconditioning, the sand is fed into side-tipping wagons running along a gangway on rails at the crane level outside the main foundry. They empty in chutes, which form a constant supply for each moulding machine. The cupolas are fed from specially designed skips of the blast furnace variety. They are designed to take one complete charge. They are first placed on a weighing machine, having, say, three fixed pointers. Pig, etc., is charged in until the moving pointer checks up with the first stationary pointer. A second addition is stopped when coincidence is made with the second fixed needle, and so on. Then it is taken to a second weighing machine, where the fuel and flux additions are similarly treated. The behaviour of every cupola is controlled by half-hourly samples, which show up hardness and viscosity.

The visitors all received an excellent impression of the conduct of the various foundries inspected, and particularly admired the efforts made to reduce handling costs and to ensure quality.

Chilled Roll Making.

Some Broader Metallurgical Aspects.

By "Corbus."

(*Continued from page* 294.)

The Future.

The future prospects of the roll trade must be a matter for serious thought; it is very certain that working conditions for rolls will continually become more and more severe, raw materials will not improve in quality, while coal supplies will tend both to deteriorate in quality and to become more restricted as to choice of type. Thus the two main problems of the roll maker will become more and more acute—quality of product and economy of process. As regards quality, the first essential is a more narrow control of existing factors during the process of manufacture. The caster should depend upon temperature rather than phosphorus content for fluidity, but this temperature must be attained without oxidising the metal or "stewing" it for a long time in the furnace; this implies a study of combustion conditions:—The amount of air supplied, the question of secondary air introduced (with great care and careful control) on the stack side of the fire, qualities of coal, methods of firing, speed and degree of combustion, analyses of the flue-gas, furnace atmosphere and slag condition, and the design of the furnace as affecting all these matters. The writer has found cases where furnace atmosphere and temperature varied enormously within short intervals of time without the slightest intention on the part of the melter. Proper control of the bath under these conditions is impossible. If a furnace is timed from when the door is closed after charging till the tap-out and the progress of the melt watched, the time taken can be analysed into:—(*a*) Melting time; (*b*) heating up time (if any); and (*c*) physicing time.

Given the weight of the charge, "*a*" can be calculated into "cwts. per hour." This figure should be a fairly constant one for similar charges, and its daily calculation gives a good check on the condition of the furnace, other things being equal, and its working. A furnace in good condition, not overcharged, and fired properly with good coal should not require much heating up time once the metal is melted, and appreciable entries under "*b*" are a symptom calling for attention.

Physicing time should obviously be as low as possible, and two matters jump to the mind in this connection: First, that if the scrap charged were studied as carefully as the pig-iron, and the analysis of *both* known, it would be possible to "pitch" the correct chill-depth much more accurately than is generally now done, and in conjunction with more exact furnace control this would minimise the necessity for physicing, thus giving a good hot metal in a minimum of time. Secondly, where physicing *has* to be done, in the case where chill is to be decreased, there is still much prejudice against the use of ferro-alloys as opposed to the "soft" irons containing 3.0 to 4.0 per cent. Si. It is obvious that the main effect of the soft iron is to add silicon to the bath; why not, therefore, add it in a more concentrated form, thus saving time and fuel and eliminating oxidation. Some people would call this "doping" the metal, but ferro-silicon is no more "dope" than soft iron.

One cwt. of 3.5 per cent. Si. pig-iron contains 3.92 lbs. of silicon, the equivalent of this being, of course, 7.84 lbs. of the 50 per cent. alloy—comment is needless. A little care is necessary in getting the ferro-silicon into the bath, of course. It is stated above that analysis of bath pig-iron and scrap should be known, and it may be objected that though pig-iron can be sampled in batches, to analyse every piece of old roll is impracticable; the writer quite agrees, and would add that it is unnecessary; every roll foundry should have a very large stockyard and the pig should be stacked in piles or bins, each batch separate, that is, not each make, but each batch, the buying department arranging that uniform batches as large as possible be bought.

The old rolls go into one big pile from which they are selected for individual furnace charges or may even go direct to their charge bins, at the discretion of the foundry executive who knows his melting programme, and who has sufficient charge bins to lay out the scrap portion (only) of each furnace charge two or three days ahead, the weight of each piece is either rough estimated or taken by means of a spring weigher slung on the crane hook—when lifting the piece to its bin. This weight is noted or painted on the piece. The pieces are then drilled for sampling with a portable electric drill, and a composite sample is made up for each bin, *i.e.*, for each furnace charge, the weights of drillings taken being in proportion to the weights of the respective scrap half rolls or rolls. It is necessary to powder the drillings in an agate mortar and mix them thoroughly, when a sample sufficiently accurate for this type of work is obtained.

When the time comes to use a certain charge there is a given weight of old rolls of known average analysis; it is a simple matter to adjust the proportions of the pig-irons and shop scrap, also of known analyses, to suit requirements, and the pig-irons are brought from their respective batch piles straight to the furnace. The tapped metal also would be systematically analysed, and when scrap rolls bearing the establishment's own mark and cast series number come up for remelting in the course of time it is a simple matter to look up their analysis. Thus there is a charge of known composition going into a furnace designed and fired to give a high temperature with control over flame and atmosphere—and it is along these lines, coupled with control of the slag, rather than by means of any secret mixtures or special brands of iron, that progress will be made.

Factors Affecting Chill.

All the following factors affect the quality of the metal and the depth of chill obtained:—Carbon, silicon, sulphur, phosphorus and manganese contents; rate of cooling; casting temperature; amount of gas dissolved, possibly the highest temperature to which it has been subjected in the furnace, and possibly a factor compounded of the previous histories of the various irons involved in the charge. This being so, it is obvious that various combinations of these factors can hold good for any given result in chill depth, and there is need for much study as to the best ways of combining them, close observation of the micro and macro structures of both chill and core for given analyses and thermal data will give much vital knowledge.

The regular achievement of fine nodular graphitisation and a maximum pearlitic matrix in the cores of rolls, for example, is a point very worthy of study, and it is high time that the microscope began to play its rightful part in helping the roll maker, as it has helped the steel maker, and is now helping the grey-iron founder.

Economies to be Effected.

Economy of process is a matter now urgently demanding attention from the roll foundryman as it never has in the past. Hitherto he has used the most expensive of materials and fuel in the most slow and wasteful type of furnace and carried out adjustments of metal condition in a manner quite regardless of cost. Quality must always come first, but it need not be lowered, in fact it can be raised along with a reduction in cost by more careful consideration of what is happening and what we are doing and why. First of all—fuel—the need for study of combustion conditions has already been emphasised, and in particular the control of primary and

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secondary air supplies to suit the supply of combustible matter in the grate and combustion chamber will certainly give the maximum heating effect from a given quantity of fuel, always with an eye on furnace atmosphere and metallurgical conditions. The possibility of some form of mechanical stoking is a most interesting one and though the writer has not seen any such system at work on metallurgical furnaces, he considers that a mechanically sound plant of this type, properly adapted to the purpose would probably give certain distinct advantages and be well worth investigation.

Gas Firing.

To carry things a step further, gas firing would seem at first sight to offer great advantages, but has never attained any popularity, though it has been tried several times. It is possible that the properties of a gas flame are less suitable for this purpose than those of a flame coming direct off a high-temperature bed of solid fuel and containing a high proportion of solid particles, but the writer feels sure that the question of gas-firing warrants much more investigation than it has hitherto received.

In the United States attempts have been made to melt roll metal in regenerative open-hearth furnaces of the type used for steel making, but great difficulty was experienced in controlling the carbon content. It is probable that these experiments were carried out with insufficient attention to the special characteristics and needs of roll iron.

In open-hearth steel making very oxidising conditions are necessary during melting down and the early stages of refining to oxidise carbon and silicon, and furnaces are designed with this end in view: it is very possible that a modified type of open-hearth furnace, designed specifically for the purpose would give satisfactory results in the melting of metal for rolls.

Pulverised Fuel.

The interesting and contentious subject of pulverised fuel also suggests itself for consideration: in the United States pulverised fuel has attained a wide usage, more particularly in steam raising, cement making, roasting, and similar plants where there is no molten metal bath to be dealt with; the writer has heard directly of only one molten metal process where this type of firing has been used, and that was in copper refining, where it appeared to be fairly successful."

It is probable that certain questions would have to be explored carefully before pulverised fuel could be used with technical success for roll metal melting, *e.g.*, the cutting action of the flame on refractories in small furnaces, furnace atmosphere in conjunction with efficient combustion, the controlling of this atmosphere, the action of incandescent ash particles, along with the refractory fused by them, on the slag (for it must be remembered that in this system all the ash goes through the furnace with the flame), and sulphur transference from fuel to iron, etc.

A Suggested Duplex Process.

All these developments in firing (mechanical stoking, gas, powdered fuel, etc.) would, of course, only justify their extra complication provided they gave a very marked increase in furnace control, thus beneficially affecting the quality of the roll metal, and marked decrease in fuel or running costs. It is highly probable that any system of firing which gave a close degree of control would automatically effect great fuel savings, as a great amount of combustible matter is wasted at the present time. Future increase of furnace size may, of course, absolutely necessitate the supersession of direct hand-firing of "raw" coal.

Turning from questions connected with the present type of reverberatory furnace to broader aspects—one thought stands out. For roll purposes the reverberatory furnace is an efficient refining unit and can take large pieces of scrap but is an inefficient melting unit, whereas the cupola is an efficient melting unit, but an inefficient refining unit; why not therefore melt all the pig-iron and small scrap in the cupola charging old rolls and big heads only into the furnace, and melt them with the powerful aid of doses of very hot metal from the cupola. The cupola metal would be run, as it was melted, into the furnace, where the whole melt would be sampled and adjusted (as necessary) in the usual way. One cupola would feed two furnaces and a high rate of output could be obtained.

It is true that cupola-melted metal in the past would not have been admissible even as half of the charge for rolls of the highest quality, but with modern metallurgical control it is possible to make a splendid quality of iron in the cupola at a very low cost. This also opens the door to great economies in the raw materials since it is possible to turn out regularly with a good cupola using steel scrap and medium-grade hematite pig-iron, a product which after refining in the air furnace will compete with "cold blast" quality.

Special Elements.

The idea of alloying nickel, chromium, and other such special elements with cast iron has occupied much attention of late, and there is a danger that roll founders may be tempted to hope that some such procedure will meet their difficulties and prove a panacea, but two points must be emphasised—first that any use of these expensive alloying elements will necessitate both on commercial and on technical grounds a full development of melting facilities and control: second, that a very close knowledge of the subject is called for when attempting to make these alloy irons; for instance, in making nickel steel it is not sufficient merely to introduce so much per cent. of nickel into a steel containing the correct proportion of the other elements, the heat treatment of the product must be carefully planned and executed or indifferent results will be obtained.

Undoubtedly there will be new problems for the roll maker when he starts to use these alloys—broadly, it may be said that while the introduction of an alloying element or elements gives various immediate results, the most important one by far lies in that the resultant product becomes highly susceptible to the effects of any treatment it may receive, thus enabling wonderful results to be obtained when conditions and treatment are correct for the purpose in view, but conversely imposing stricter limits on the conditions and treatment than hold good for "straight" steel and iron.

However, provided these matters are taken into account and the subject approached with care and knowledge, it is probable that results very valuable to the roll maker will in due course be obtained from the use of alloying elements. The use of chromium to improve the stability and hardness of the cementitic-chilled structure at the working temperatures of hot rolls is a very fascinating matter, since it is surely possible to evolve on a commercial basis a material both harder, tougher, and more retentive of its qualities at high temperatures than chilled white iron.

American Foundrymen's Association.

Amongst the Papers expected to be submitted to the Chicago meeting, to be held on June 6, 7, and 8, are the following:—

"Specifications for Miscellaneous Foundry Materials," by V. A. Crosby, metallurgist, Studebaker Corporation, South Bend, Ind.

"Mould Drying," by J. M. Sampson, the General Electric Company, Schenectady, N.Y.

"An Analysis of 400 Tons of Defective Castings," by J. M. Hanley, Crompton and Knowles Loom Works, Worcester, Mass.

"A Study of Chapleting," by M. Varlet, S.A. Esperance Longdoz, Liège, Belgium, Exchange Paper of the Belgian Foundry Technical Association.

"Fatigue of Cast Iron," by H. F. Moore and S. W. Lyon, University of Illinois, Urbana, Ill.

"The Coulability Bar" (a bar for testing the "life" of cast iron), by Charles Curry, Ardennes, France, Exchange Paper of the French Foundry Technical Association.

"Some Graphite Formations in Gray Cast Iron," by J. W. Bolton, the Lunkenheimer Company, Cincinnati.

"Some Points of Steel Foundry Practice," by E. R. Young, Detroit Steel Casting Company, Detroit.

"Foundry Sand Control," by M. Kuniansky, Lynchburg Foundry Company, Lynchburg, Va.

The British Exchange Paper is being written by Dr. Andrews.

A New Sand Mixer and Aerator.

The complete mixing and aeration of foundry sand is one of the most necessary and at the same time the most difficult problems which the foundry manager has to face. That these facts have been recognised is evidenced by the number of disintegrators which have from time to time been placed upon the market; generally, however, all such plants have been designed with a view to centralisation of the sand preparing and mixing. In the large foundry a sand-mixing shop is no doubt essential, but unless this shop is served by a somewhat elaborate conveying and handling system, the necessary collection and distribution represent a heavy labour charge. Indeed, the conveying of either facing or backing sand, or, for that matter, old sand back to the sand-preparation plant, is a proposition for which, up to the present, no solution of a satisfactory and lasting nature has been evolved.

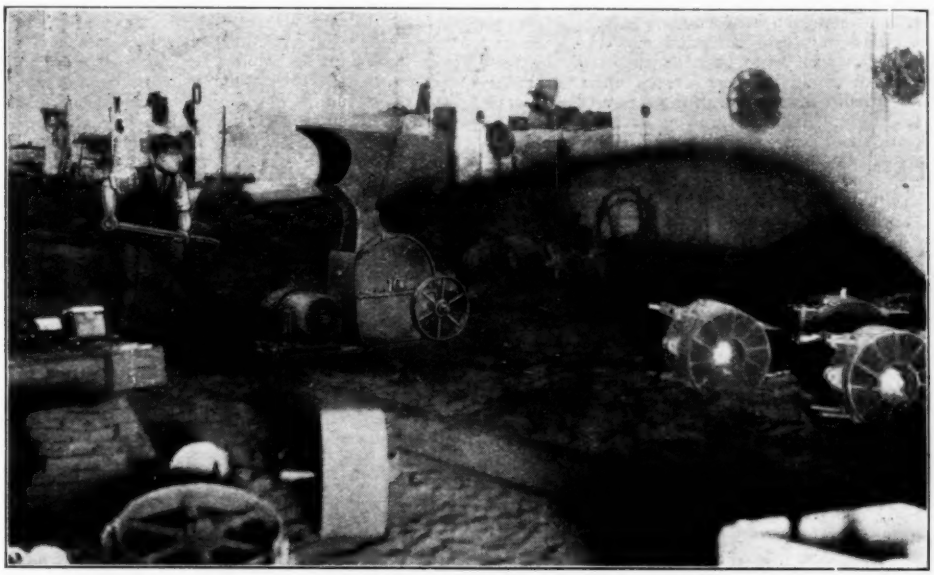
In very many foundries certain of the castings are made in the foundry floor, and thus the reconditioning of the sand, if it is to be done in a central plant, amounts to nothing less than the temporary removal of a portion of the foundry floor space. It is not necessary to labour the advantages of a portable machine for such a duty; they are obvious.

On a recent visit to the foundry of Messrs. Thomas Robinson & Son, Limited, Railway Works, Rochdale, our representative had an opportunity of seeing a novel form of machine (Patent No. 267261) supplied by the Universal System of Machine Moulding and Machinery Company, Limited, 97, Queen Victoria Street, London.

This machine really combines the functions of disintegrator, mixer, aerator, and, within limits, also conveyor. It is an entirely self-contained unit mounted with its driving motor on a common base which is fitted at the fore-end with a pair of travelling wheels, and at the rear with sockets for the reception of handles. As the complete outfit weighs approximately 4 cwts. it is easily portable; indeed, it is being used as a strictly portable machine by Messrs. Robinson for the reconditioning of sand on site.

As will be seen from the illustration, the machine is of the simplest possible construction, and is entirely of British manufacture. The essential feature is a steel drum the periphery of which is drilled for the reception of a number of 1½-in. × ½-in. rivets, which are equally spaced transversely across the drum. The drum shaft is mounted on ball bearings carried in housings formed in the side members of the framing. The upper portion of this framing follows the contour of the drum, and is provided with an outwardly-extending flange, this last serving to form the runway for the feed hopper which is secured to the flange by means of set-screws so that the position of the hopper opening can be moved backwards or forwards according to the direction in which it is desired to effect the discharge, *i.e.*, at floor level or at some distance above the floor when the machine is feeding into a hopper serving a machine or machines, the delivery side of the hopper is further provided with an adjustable gate or plate which can be raised or lowered according to the fineness or grade of the sand required. The drum is driven at a high peripheral speed direct from the motor through a "Whittle" pulley and belt. The motor, which is 2 h.p. and of the totally-enclosed type, is provided with tension screws for taking up any slack in the belt.

The action of the machine differs from any other we have hitherto seen. The high peripheral speed maintains the sand in suspension, and it never actually comes into contact with the surface of the drum, but, by means of the studs, is rolled over and over again in the hopper, thus being thoroughly combed and perfectly aerated. Immediately the sand comes into contact with the adjustable plate at the delivery side of the hopper, the plate actually performing the functions of a sieve, the rolling action is stopped and the sand is ejected. Owing to the sieving action of the adjustable plate, any sand requiring a lot of disintegrating and combing is automatically kept in the hopper until it is fine enough to be thrown. The machine illustrated has a capacity of at least 5 tons per hour—the figure can only be assumed, as within very wide limits it would seem to be governed only by the ability to feed; with two men shovelling it was found impossible to stall the machine.



A New Sand Mixer and Aerator.

Another interesting effect of the high peripheral speed is the rejection of tramp iron, which is promptly thrown out and up against the inclined hood over the feed hopper, passing thence to the foundry floor.

The sand produced is of a beautiful silky texture, and the stream of it can be thrown approximately 20 ft. from the point of ejection, the direction of delivery being, as already stated, controllable.

The only wearing parts are the rivets, which, being a driving fit in the holes (when running their position is, of course, maintained by centrifugal force), could be readily renewed in, say, a couple of hours. In the machine inspected mild-steel rivets were used, and on all counts these will probably best meet the requirements. Manganese steel might, of course, be employed, but for this particular duty mild steel is to be preferred, especially as the cost of renewal is so

small, only about 28 lbs. of rivets being required for a complete renewal.

Whilst the machine is essentially portable, it is, of course, not of necessity so, and might well form a unit in the central plant. Under such conditions, and in order to obtain the highest efficiency, it would no doubt be found an advantage to feed the machine from an elevated hopper. To the comparatively small foundry this type of machine will make a strong appeal, and where it is not possible or convenient to adopt the electrical drive a belt drive could be substituted.

Corrosion of Iron and Steel.

In a Paper on this subject, submitted by Messrs. W. B. Lewis and G. S. Irving before the Engineer Surveyors' Association in London, the authors, after a historical review of the subject, mainly on the theoretical side, gave a series of demonstrations. Discussing the subject in its bearing upon boiler practice, they remarked that, supposing corrosion was going on in a boiler, there might be a few spots covered with a deposit, with the rest of the boiler fairly clean. Oxygen was being continually supplied by the incoming feed water, and this maintained the corrosion in the presence of various salts which were there. The part not corroded was the cathode, and, as this was large in area, most of the corrosive effect would be concentrated upon the much smaller anodic areas. Crannies or "pits" were formed there. When corrosion of this type was going on, there was generally produced a sparingly soluble substance, but not just at the seat of the corrosion, so that further attack was not prevented. On the contrary, as Evans had pointed out, it would shield the interior of the cranny from oxygen, and thus facilitate the corrosion. The rate of penetration under the conditions just mentioned became rapid, with the result that pitting occurred—*i.e.*, isolated crannies which had penetrated into the metal. The more "pits" there were in a boiler the more general the corrosion, but the less the depth of it would be. Where serious pitting occurred at only a few places, it might quickly penetrate to a sufficient depth to necessitate the removal of that plate or tube from the boiler, whereas a more general type of corrosion might take months or years before renewal of the parts was required. At the elevated temperature of a steam boiler, magnesium chloride in the presence of iron split up, giving eventually hydrate of magnesium and hydrochloric acid. The acid attacked the iron, no doubt on the lines of the ordinary hydrogen type of corrosion. It had been shown that the corrosion of mild steel by 4 per cent. hydrochloric acid proceeded fifteen times as quickly in the presence of oxygen as when it was absent. The hydrochloric acid attacked the iron, with the formation of iron chloride, but this was attacked by the water, resulting in the formation of black oxide of iron (the well-known graphitic type of corrosion) and hydrochloric acid. The same acid then attacked some more of the metal, so that the magnesium chloride acted as a kind of catalytic agent. In evaporators this could reach such an extent that a portion of the hydrochloric acid might be distilled over with the steam before it had had a chance of attacking the metal of the evaporator. The acid mixed with the condensate, resulting in a most destructive effect on the boiler; hence the advisability of not having too great a density of the water in the evaporator.

Calcium nitrate, calcium chloride, magnesium chloride, magnesium nitrate, carbonic-acid gas (carbon dioxide), and oxygen were the chief corrosive substances in boiler feed waters, and it was their influence and effect which had to be neutralised if corrosion was to be prevented. Degassing plants could certainly remove a large amount of oxygen and carbonic-acid gas, and decrease corrosion, but they did not remove the soluble salts mentioned, which were capable of causing corrosion in a boiler—chiefly of the hydrogen type. Even when oxygen was reduced to a minimum in the feed water—either by vacuum degassing, or passing through steel turnings—the feed water might contain nearly as much free oxygen as it originally contained owing to defective pumps, or other agencies putting air or oxygen into the water.

As the chief type of corrosion in steam boilers was due to differential aeration, the importance of keeping boilers free from scale would be realised. Further, when a boiler was opened up and was found to be patchy—both on the tubes, combustion chambers and plates—the opportunity should be taken of removing as much as possible of any loose deposits. When new tubes were put in, similar remarks applied to the old tubes. Where any active corrosion had been found to be going on, as shown by patches of rust or black oxide of iron, they should be cleaned and wire-brushed, so as to assist in stopping further corrosion of the pitting type due to the presence of rust. Other conditions being equal, the softer the water the less scale formation there would be, and, if any information was obtainable as to the suitability of the water from a corrosion point of view, all the better. Vegetable matter, when decaying, gave rise to what were called humic acids, and moorland waters often contained vegetable acids, which exerted a decidedly corrosive action on boilers.

Faulty Crucibles.

Crucibles are of uniformly high quality, and if they deteriorate rapidly it is almost invariably the fault of the user. The average user of crucibles may be familiar with many causes of pinholes, but it is not so generally known that the scrap metal is often the cause. Impurities are introduced into the crucible with the scrap metal that has to be melted, and scrap varies in its impure contents and its degree of possible effects on the metal and the crucible. Sometimes scrap may be employed which has been taken from chemical works or been used for conveying matter which has corroded or left a residue on the interior of the scrap metal. Such encrusted scrap metal very often has a pernicious effect upon the crucible, and it may develop pinholes. Occasionally a poor lot of scrap is dumped into the foundry, which carries a cyanide, and as cyanide attacks crucibles and forms pinholes the useful life of crucibles, however good they may be, or however carefully they may be annealed, is considerably reduced.

The coke furnace may be stoked wrongly and be responsible for pinholes, particularly when the temperature is high, as the crucible is comparatively soft when very hot, and forcing coke against it in such a condition hastens the connection with the internal fracture which may be present. Even gas or oil-fired furnaces are not immune in this respect, although the effect on the crucible is not as severe as with coke. When the flame impinges the crucible, although it may resist shelling, pinholes will eventually develop. Then a bad mixture of air and gas is detrimental to the crucible, particularly when the air volume is too great and a graphite crucible is used, then free oxygen acts upon the graphite and reduces the crucible, which ultimately makes it subject to blowholes. Improper handling and bad fitting tongs are other causes of blowholes. Local fractures are produced, and the metal soon finds an outlet.

Improper or hasty annealing will sometimes permit a crucible to enter the furnace without showing any indication of a fracture; at the same time the fracture is there, and after a few heats the metal will follow it, sometimes finding an exit several inches from where it started. This is the most common form; it seldom happens that a pinhole makes a direct passage through the crucible wall unless it has been worn very thin. Some crucibles which have developed pinholes after a few heats will, when broken up, show a network of metal woven into the wall. A condition of this kind invariably indicates that the crucible was too hastily annealed, which caused an internal fracture that did not develop into a scalp, or the annealing process may not have been sufficiently completed to prevent an internal fracture after it was placed in the furnace. Certain kinds of fluxes are directly responsible for pinholes, forming, as they do, chemical combinations with the metal which attack the crucible. J. M.

Sand Moulding Practice.*

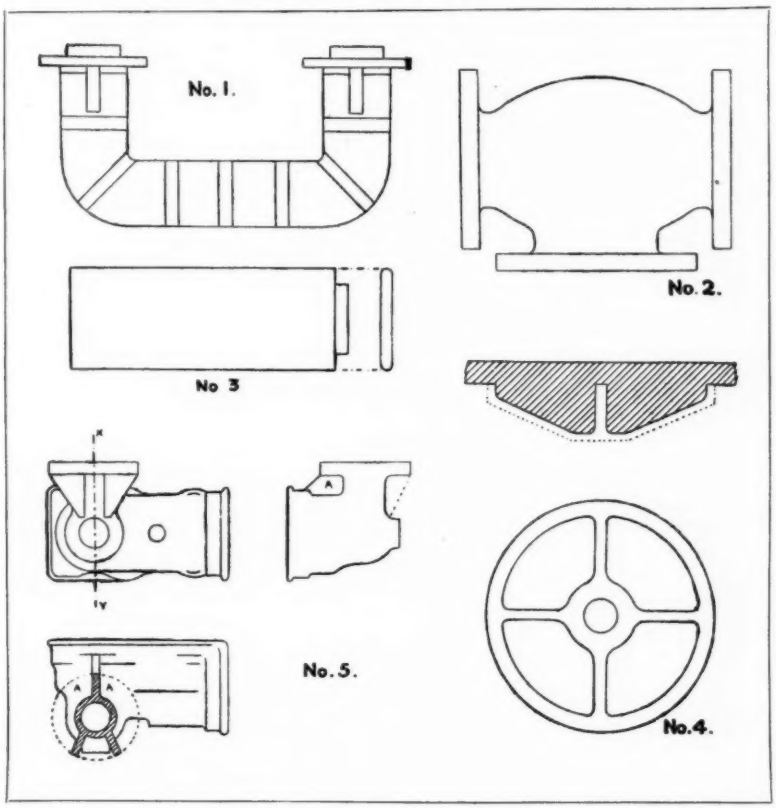
By J. D. Nicholson.

A foundry engaged upon machine moulding or repetition moulds has, more or less in every operation, a certain amount of standardisation, and the loose expressions too hard, too soft, etc., are practically eliminated. During the course of time moulding practice has changed very little, and this Paper deals with some of the essential moulding principles it is necessary to perform correctly and the ill-effects produced if they are not followed.

In a jobbing foundry engaged upon work which comprises light and heavy castings such as are used in the manufacture of marine steam and oil engines and turbines, and castings of special metals, moulding practice must be carefully considered. With such a diversity of work made moulder according to the type of mould to be made. Thin moulds are preferable made with old sand. Pipes require a weak facing, especially upon top parts. The combustion set up from the coal dust retards, to a certain degree, the flow of the iron, and increases the possibility of cold shut. Notwithstanding the low permeability of the sand, the absence of sand erosion or scabbing from the nature of the sand itself is noteworthy, being more attributed to ignoring the three features previously mentioned.

Ramming.

Ramming may be said to be the primary factor in moulding. Correct ramming should be the aim of young foundrymen. As variation of ramming



from patterns of the solid and skeleton types, it will be seen that, unlike other branches of sand moulding, it is impossible to give a definite meaning to the loose expressions mentioned. Excluding the character of the base sand, it might be said that nothing can be taken as a constant. The subject might conveniently be called hand moulding practice.

Throughout the Paper the base sand used is Erith Yellow Loam, a sand fine in texture, possessing a good bond but low in permeability. The time limit imposed by the freezing iron for reactions to free themselves is so short that it is imperative that the mould must be so made for reactions to be at a minimum, as these few seconds generally decide the quality of the casting. One might say that a sound casting from a sand mould is dominated by three outstanding factors in moulding practice: (1) Ramming of sand; (2) speed with which generated gases and steam pass from the mould; and (3) running the mould.

For green-sand work proportions of new sand, old sand and coal dust are mixed together as a facing. This may again be revised by the is necessary with different parts of a mould, its attainment is a strong item in the production of sound castings. The pressure of the iron increasing as depth of the mould increases makes it necessary to ram more soundly. Soft parts of a mould "give" to this pressure, resulting in swellings upon the casting. This is sometimes seen upon a pipe made from a skeleton similar to Fig. 1 pattern. The scooped-out portion of the mould have not been made sound like the rib guides.

Excessive ramming increases the density, thereby resisting the immediate escape of gases and steam formed when filling the mould. These, prevented from passing through the sand, break through the mould face, and the result is a scab upon the casting. This is the primary cause of scabbing upon a bracket connecting two flanges. Parts of sand having too much water content, perhaps gained from swabbing the mould after withdrawing the pattern, give off a series of bubbles when in contact with the iron. These may eventually free themselves, yet a possibility remains of their being trapped in the iron. A globe valve (Fig. 2), with its fragile projecting pieces and body sometimes thinner than the

* A Paper read before the East Midlands Branch of the Institute of British Foundrymen, held at The College, Loughborough.

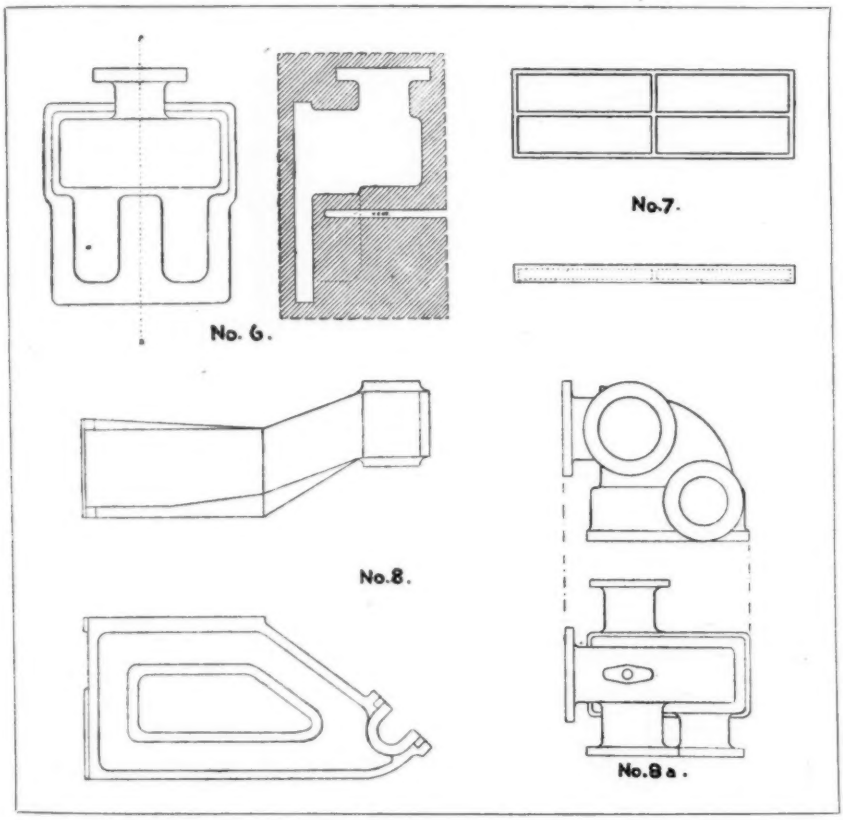
flanges, gives a fair illustration. One has an excellent example of the formation of these bubbles when burning a piece of a flange upon a casting. If the loam cake is damp bubbles will continue to rise until the iron freezes. After machining numerous pinholes will be seen.

A good test of soundness in ramming is obtained when moulding in green sand a plate 6 ft. long by 2 ft. 6 in. wide by 2½ in. thick (Fig. 3). Floor-moulded and run at the end, the casting is machined top and bottom. Any irregular ramming will result in scabbing or swellings. The pattern may be laid upon a specially levelled sand bed or simply bedded upon the soft sand. The first ramming in the top box must be done carefully. Here, as in similar flat parts which become the face of the mould, the peg rammer must not be heavy or blunt. One with a peg 2 in. wide, 2½ in. deep, and ¾ in. thick, but worn, is convenient. A blunt peg rams solid, usually making a joint, in places, between two rammings, with the result that dropped tops occur. Other reasons for drop-outs are a dry facing, a warm box, or steaming old sand. The plate is run with sprays at the end. The constant beat of the iron upon the mould face tends to cut into the sand. This is prevented by sprigging and smearing this part with plumbago. Dusting the top part above the runners also resists the scorching effect of the iron. A pump bucket (Fig. 4) is another example of projecting parts being safeguarded by dusting with plumbago.

Venting.

The uncertainty of ramming pressure makes it advisable to resort to artificial means to increase porosity and to minimise ill-effects. Means adopted are the vent wire and pieces of straw, although cases arise where a trail of fine ashes is laid or a cinder bed inserted as a definite outlet for generated mould gases. It must not be taken for granted that the vent wire is a complete remedy for hard-rammed moulds. In all floor-moulds the sand should be well loosened, or opened up, 12 in. below the required working depth. Blowholes are sometimes found in top branches and top brackets, generally above a neck of sand. They may be attributed to this neck of sand being too dense or damp (Fig. 5). During ramming sprigs of straw inserted will facilitate the escape of gases and steam.

An auxiliary discharge test is (Fig. 6) an illustration of how gases, formed as the iron is filling in the bottom of the mould, may be diverted through an ash channel to the box edge, instead of continuing upward and breaking through the mould face (Fig. 7). A plate 8 ft. long by 3 ft. wide by 1½ in. thick, with a flange round the outside 5 in. deep, floor-moulded, is an instance where a cinder bed is laid in the floor as a passage for the generated gases from the enclosed body of sand. The ashes are laid about 12 in. below the bottom of the mould. A pipe leads from the bed to the floor level. Paper or teased straw may cover the ashes to prevent sand streaming among them with the possibility of choking the bed. Old sand is added and the mould commenced from the required depth. The vent wire is probed from the mould face to the ash bed, making a complete passage for the gases to find their freedom through the pipe.



Moulds having large cods of sand, such as weigh-shaft brackets (Fig. 8), if moulded turnover method and vented with the ⅜-in. wire, will receive greater freedom for gases than if floor-moulded. Of course, the cod must be strengthened with irons to ensure stability when pouring.

The flat plate previously referred to is a type where venting with the wire must not be neglected. The end view shows how the bottom may be vented to meet the vent holes at the side.

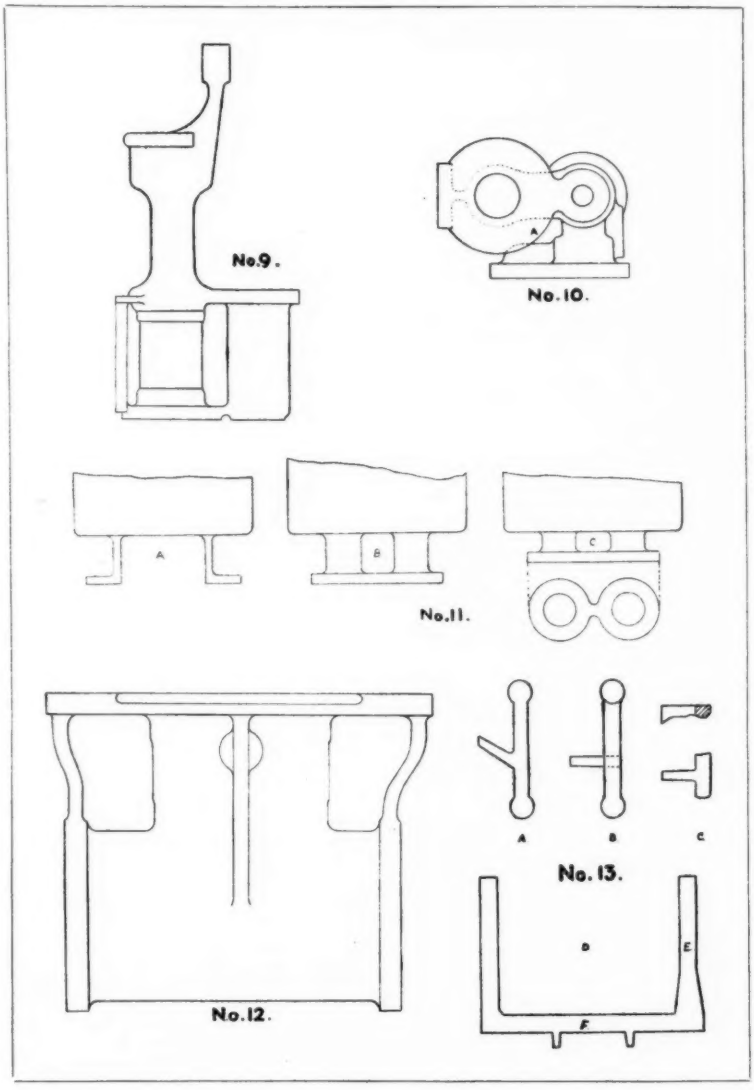
Moulding boxes in a jobbing foundry are seldom made for one class of job. Tackle such as lifters and grates might be plentiful. In top parts curved surfaces bind themselves upon the keystone principle, but flat parts require grates to carry them. These must be smeared carefully with clay-water. Otherwise the layer of sand below the grate, about ¼ in. or ⅜ in. thick, constituting the face of the mould, becomes overburdened with clay content and peels off the grate when touched by the metal. This is more evident when a flat piece of grate is used.

Dried Moulds.

Owing to the severe test required of modern engineering castings such as Diesel engine parts, superheated steam valves, stop valves, etc., it is

necessary to use dried moulds to ensure soundness. The aim is to have a sufficiently dried mould, and precautions might be taken to facilitate drying by stoved moulds being separated into several parts. Old backing sand need only be damp enough to bind together, and greater use might be made of the ¾-in. vent wire.

One can realise that very little gas comes from a dried mould while it is being poured. The deciding factor in the success of the casting is to prevent any steam formed in the sand whilst filling with iron affecting the mould face. Where there is a possibility of this one might take precautions to avoid it when making the mould.



Dry sand is composed of new sand plus old sand. Water is added during milling, making it plastic. The sand has a good bond, and excessive ramming need not be done, as the sand, when dried, is strong enough to resist the pressure exerted in the general class of castings made in two- or three-part moulds. Many complicated moulds are made having numerous cods of sand, pockets and prominent pieces. It is obvious that excessive ramming, more so than in green sand, increases the density, thus retarding efficient drying. A local spot of expanded steam will make its escape the easiest way, which is through the dried part, it being the most porous and constituting the mould face. Sometimes the steam presses a piece of sand into the iron, which is usually called a buckle. A buckle occurs some seconds after the metal has rested on the part or against the part where the buckle is seen. A scab or mould erosion occurs through the face of the mould itself being damp. The agitation between metal and dampness brings away a part of the sand about ¼ in. or ⅜ in. deep. Sand erosion is also caused by too little backwash being applied to the mould.

Valves with several bottom branches or feet are prone to buckles upon the flat body. One realises the face of the mould is dry to a certain depth, yet in enclosed bodies of sand as seen between flange and body it is not dry throughout. The iron filling the bottom naturally causes steam to expand in these parts. Provision may be made for this during moulding by cutting a channel between each branch to the edge of the box and filling with fine ashes. These vents should be wider at the box edge to lessen the risk of the vent choking. Core print vent holes in a mould bottom may be large to facilitate drying.

Stop valves have a projecting piece of sand between bottom flange and body. At one point it is 2½ in. into the mould and 2 in. thick, and adjoins a large mass of sand. The dryness of these two parts of the mould can be imagined; gases emanating from this projecting piece of sand, which is similar to a core, will pass into the iron. This may be a cause of pinholes being found in valve seatings. To avoid this a piece of wax vent a few inches long is laid in the sand and led into a tube which is withdrawn when ramming is finished. In a main engine stop valve large brackets appear. When ramming upon a turnover board (Fig. 12), a round gate pin 2 in. diameter may be inserted 2 in. from the face of the bracket and withdrawn when rammed up. These holes allow the brackets to receive a better drying.

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Loam.

Recent years have brought into use the practice of using loam for parts of dry sand moulds. Whilst it may be used where strength is required of fragile parts, and awkward places where a good lift is desired, it should not be used to excess owing to the difference in drying between loam and sand. Loam attracts damp very readily. One might work a little milled sand into the loam with the hands in these parts.

Runners.

The running of moulds in jobbing work is a complex item. The type of mould and purpose of the casting calls for much thought upon how a mould should be run. It is an operation in which experience gives the desired result, as often methods are entirely of a reverse order. Round downgates or flat may be used as convenient, although round gates will admit of the feeding rod or extra metal if any blowing occurs. Inlets into a mould must have a total sectional area less than the area of the downgate.

In green sand especially sharp running increases mould blowing by lessening the time for steam and gases from the mould and cores to free themselves. With medium pouring, providing the iron is suitable, little risk is attended of blows being trapped in the metal. If an inlet be cut in the lowest part of the mould, and any immediate blowing occurs from a local spot, the incoming metal may help the bubbles to reach the surface of the metal. One might conclude that no addition of metal will affect any commotions taking place below the level of the inlet. For pipes and thin moulds sprays are preferable.

Much can be seen when pouring an open sand mould as regards scum gathering and sticking to the side of the mould. Scum is more often met with in green-sand moulds than in dry-sand moulds. In dried moulds the runner bush may be dried as a further preventive. The custom is to cut a channel in the mould joint between the downgate and the inlet. To cut this channel in the joint of the top part (Fig. 13, D) would tend for slag or dirt, which may have passed through the downgate to lodge itself in the uppermost part of the channel. The inlets are cut in the bottom joint, thus allowing the cleanest iron to enter the mould. This is a good type of runner for moulds whose castings must machine perfectly clean. The dry-sand moulds to be cast vertically may have spray inlets on the top, sides or bottom, as convenient. The downgate, when run in the bottom, may have an extension beyond the inlet and a heel slightly above as a trap for any dirt or slag which may pass into the downgate. Modern types of castings with their special metals reverse the usual order. The tendency is to fill the mould as sharply as possible, and owing to the amount of shrinkage taking place to use large risers and feeding heads.

With green-sand moulds it is essential for the mould risers to be sealed during pouring. The sealing allows the pressure exerted by the incoming iron to force the mould gases through the sand, to escape by the natural and artificial exits provided, otherwise the mould gases would roar at the risers. The suction in the mould thus exerted would pull the mould to pieces, and encourage the top parts to drop. Dry-sand moulds do not usually have closed risers, although if a mould has weak parts or weak intricate cores it is preferable to cover the risers with a piece of clay.

In conclusion, whilst in the present times minds are bent upon machine and mass production, there is abundant scope for the jobbing moulder in modern castings for thought and individualism. Finally, the author wishes to express his thanks to his employers, the North-Eastern Marine Engineering Company, Limited, Wallsend-on-Tyne, for allowing him to give this Paper, and to their laboratory for assistance with the slides.

Pig-iron Purchasing Bureau in Poland.—A central bureau is to be established in Poland for the purchase of pig-iron in order to make the country's industry independent of Germany, which country now supplies about 80 per cent. of the Polish pig-iron imports.

Institute of British Foundrymen.

Lancashire Junior Section.

The annual meeting of this section was held on Saturday week at the Manchester College of Technology, Mr. W. Jolley presiding.

Mr. C. F. Brereton (Secretary) read his report for the past twelve months. He said it had been a difficult period owing to the prolonged industrial trouble. The Council had gone through the register of members very carefully and removed the names of those who appeared to have left the Section. This had the effect of reducing the nominal membership by nearly 100, but those who remained were good, keen members, so that the Section had been really strengthened by the revision of the list. It was very desirable, however, that the subscriptions be paid promptly at the beginning of the session. The Papers read before the Section had been of a high class. No visits to works had been made because of the difficulties caused by the coal dispute, but for the coming session (1927-28) a visit to the National Gas Engine Company's works had been arranged, and others would be considered. Fifty-three candidates sat in the examination for the John Wilkinson medal and the winner was Mr. J. Yates.

The Chairman remarked that the senior members who attended the meetings of the Section had expressed high appreciation of the Papers; they were both interesting and instructive. The standard ought to be maintained, if possible, so that more of the Branch members would be induced to come. At the same time the wishes of the juniors should be considered, and the committee would be glad to hear any expression of opinion as to what type of Papers ought to be arranged for.

The secretary's report was approved, and a vote of thanks to him for his services was passed unanimously. The election of officers for the year resulted in the unopposed return of the following:—President, Mr. T. Makemson; Vice-President, Mr. R. A. Miles; Secretary and Treasurer, Mr. C. F. Brereton.

The Chairman explained that Mr. Makemson was absent because he was attending a meeting of the International Committee at Brussels. He had done more for the Junior Section than any other individual. It now held a high position in the estimation of the foundry world, and with Mr. Makemson actively associated with it as President, further success was certain.

There were twelve candidates for the committee, and a vote having been taken, the following gentlemen were elected:—Messrs. Burgess, Garside, Poole, Ward, Walsh and Yates.

The Chairman moved that the rules be amended so as to allow the winner of the John Wilkinson medal to be co-opted a member of the committee for the year. The proposal was seconded by Mr. Ollier and agreed to.

Mr. J. S. G. Primrose gave an address, in which he analysed the results of the last examination for the John Wilkinson medal, and pointed out the errors and failures of the candidates.

The Chairman said he hoped the address would be an incentive to take part in the next examination. Only one could win, but it would be meritorious to be one of the first half-dozen, and that ought to be the aim of the candidates.

A vote of thanks to Mr. Primrose was passed unanimously on the motion of Mr. Ollier, seconded by Mr. Poole.

Publication Received.

Lincoln Engineering Society's Annual Report and Proceedings, 1923-1926.

We congratulate the compiler of this—the first publication issued by the Lincoln Engineering Society. It contains an excellent editorial written above the initials of G. S. B., whom we suspect to be Mr. Gerald S. Bell. Mr. Bell is well known to the foundry industry for his work relating to the testing of cast iron. Like most engineering societies, a high percentage of the papers presented relate to metallurgical subjects, whilst quite a few treat of foundry practice.

Blast-Furnace Metal Castings.

By Our Metallurgical Correspondent.

The introduction of the foundry cupola and the remelting of blast-furnace pig-iron in this furnace, for the production of castings, is usually attributed to John Wilkinson, ironmaster, 1728-1800. The process of producing cast iron articles introduced by Abraham Darby, about 1709, a few years before Wilkinson's birth, is considered to have involved the melting of blast-furnace pig-iron in crucibles. In the long interval of years from 1540, the date of the earliest cast-iron cannon, made by Ralph Hogge and Peter Bande, at Bucksteed, Sussex, up to the time of Darby, it is probable that all the molten metal for cast-iron castings was obtained from the smelting of ores in the blast furnace direct. It may be considered, therefore, that the use of direct blast-furnace metal was the very earliest method adopted of supplying molten metal to the ironfoundry.

Exclusion from British Specifications.

If the various standard specifications for general cast-iron castings are to be regarded as an index of present day opinion on the use of direct blast-furnace metal in the foundry, then present-day opinion is distinctly antagonistic to this procedure. The British Engineering Standards' Association specification for cast-iron pipes and the tentative specification for general castings both embody a clause, specifying that the iron used shall be remelted pig-iron or a mixture of pig-iron and scrap iron. This clause indirectly prohibits the use of direct metal obtained from the smelting of iron ores in the blast furnace.

In spite of this indirect prohibition of the use of direct metal, many blast furnace men and founders have experimented from time to time on the suitability of this for general foundry purposes. The possibility of eliminating the extra costs involved in the remelting of pig-iron in the foundry cupola is a saving which is always intriguing to blast furnace and foundry owners. The loss and dissipation of heat in the production of pig-iron and the subsequent remelting of the pig-iron, using comparatively expensive foundry coke, are outstanding economic defects in our present-day methods of casting production.

Extensive Foreign Employment.

In the quantity production of some of the heavier classes of castings, direct blast-furnace metal is used. In the United States many of the large ingot mould foundries producing these castings in hematite iron operate solely on direct metal. In Germany it is reported that spigot and socket pipes are systematically produced, using direct metal, and a mixture of partly direct metal and partly remelted metal is used in the Ford foundries in America for the production of automobile cylinders. Generally speaking, the direct metal is collected at the blast furnace, and stored in large receivers or almost completely enclosed ladles, mounted on cars for transportation to the foundries. In Germany stationary metal receivers have been designed, equipped with auxiliary oil-firing arrangements for storing and maintaining the molten metal sufficiently hot. Such receivers as are in use have been designed of a comparatively small capacity, not exceeding 25 tons, and are used for maintaining a supply of direct metal to pipe-casting foundries.

In the case of automobile engine castings it has apparently been found necessary to use an admixture of cupola-melted metal with the direct metal. This class of casting is of a very special character, and may be considered to be in a class by itself, requiring the most accurate control of both the chemical composition and the temperature conditions of the molten metal to obtain successful results. The degree of accuracy of control necessary for success in this class of casting may be beyond the possibilities of direct metal, and in any event so far practical experience has demonstrated that this is the case. The fact that direct metal can be even partially used is of great importance, and at all events makes it appear that the more extended study of the application of direct metal might be worth while.

It is a matter of considerable interest to review the underlying objections to the use of direct metal and to attempt to understand why its use should be prohibited in the various specifications. Some of these underlying objections are partly a matter of difficulties of organisation, as a result of which the quality and character of the direct metal delivered to the foundry are rendered uncertain, and the supply of metal to meet the varying demands of the general foundry are difficult to maintain. Apart from objections of this nature a careful consideration of the remaining objectives show them to be based purely on prejudice, and they do not appear to constitute a sufficiently sound reason as to why the use of direct metal should be debarred by specifications.

Traditional Prejudice.

These prejudicial objections are largely based on the traditional belief that the remelting of pig-iron improves its character and quality. This belief stated in this bald manner without qualifications of any kind is distinctly erroneous. The effect of remelting on the character of pig-iron was one of the early observations made on the properties of cast iron long before the factors of chemical composition and cooling conditions were understood as they are to-day. It was observed that the continued re-melting of, say, a No. 1 pig-iron, having an open fracture, resulted in a gradual closening of the appearance of the fracture, which was accompanied by a corresponding improvement in the mechanical properties. Until the classical experiments of Professor Turner, the underlying reasons for this effect of re-melting were but imperfectly understood. They are now thoroughly well understood, and the effect was shown by Turner to be due principally to the gradual loss in silicon contents at each re-melting. Before these factors influencing the character and the quality of cast iron were so well understood the number of times the pig-iron should be re-melted to provide material suitable for various classes of castings was a common clause in many specifications. There are specifications and tender forms still extant where the metal to be used is specified as double or treble run iron, in which the iron is required to be re-melted twice or three times respectively. It is extremely important to observe that even under these conditions the character of the initial pig-iron was a matter of paramount importance. For example, the influence of two or three re-meltings on, say, a close No. 5 pig-iron would be accompanied by a change in character of the resulting iron from the grey machineable variety to the mottled and white practically non-machineable iron, as a result of the loss in silicon and the gain in sulphur of the No. 5 pig-iron which has initially a low silicon content. To guard against this it was necessary to start off with an iron of a higher initial silicon content—a more open-grained iron, in order that the final metal should have a sufficiently close grain without being too hard for machining. It will be appreciated from this explanation that the unqualified statement that re-melting improves the character of pig-iron is erroneous. The statement requires qualification by a description of the character of the initial pig-iron previous to re-melting. Modern conditions of the control of mixtures of irons for re-melting involve the mixing of different irons of different chemical compositions with the object of producing a final iron of a stipulated chemical composition. In these calculations the losses and gains of various constituents on re-melting is taken into consideration. It is generally accepted by foundrymen to-day that this method of mixing to produce a definite composition as compared with the older method of attempting to produce some "real or imaginary fracture" is accomplished by equal if not superior results.

In spite of this and the fact that the changes in composition and their resulting improvements on the mechanical properties, consequent upon the re-melting of pig-iron, are now thoroughly well understood, there is still a lingering belief that the improvement in properties is an intrinsic influence of re-melting. It is this belief which

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is largely responsible for the prejudice against the use of direct metal for castings. This belief is entirely erroneous, and it is generally agreed by all thinking foundrymen and metallurgists that the properties of iron are indentical if they are of the same chemical composition, and other conditions constant, regardless of the fact that the particular composition may have been obtained by re-melting iron or the direct smelting of iron ore.

It is necessary to refer to the influence of casting temperature. Molten metal direct from the blast furnace is usually hotter than remelted metal from the cupola. In the use of direct metal it is necessary to take into consideration the relation between the casting temperature and the casting to be produced—as, of course, is done in the case of ordinary cupola-melted metal. The use of direct metal without any precautions in this direction might be accompanied by different and inferior results than would have been expected, and from this point of view direct castings might be inferior to re-melted metal castings. If there is any difference due to this cause it will be appreciated that it is not due to the direct metal itself, but to its initial temperature, a property which it is by no means difficult to take care of.

It can be repeated that the belief that the re-melting of pig-iron intrinsically improves its properties is entirely erroneous, and if this is accepted it disposes of the prejudice against the use of direct metal and leaves us with no sound reason for debarring direct metal by specification.

Direct Metal and Sulphur Content.

The re-melting of pig-iron in the cupola is invariably accompanied by an increase in the sulphur content. Whilst the writer is one of those who hold the opinion that the dangers arising from the presence of sulphur in cast iron are considerably over-estimated, it must be admitted that the belief that sulphur is troublesome and dangerous has quite a large following. This is evidenced by the number of special desulphurising processes, involving special melting plant, the use of all kinds of special fluxes, etc., which are continually being brought to the notice of foundrymen.

It is therefore of interest to point out that the use of direct metal for castings provides a means for obtaining a lower sulphur content in the finished iron than can be obtained by any other method short of some special desulphurising process. In many quarters this might be regarded as a distinct advantage in favour of direct metal.

Other Grounds of Objection to the Use of Direct Metal.

The other grounds of objection to direct metal have already been referred to as organisation difficulties, and they divide themselves into at least two principal headings, (a) the difficulty of ensuring regularity in the chemical composition, and (b) the difficulty of maintaining a supply of molten metal to suit the varying needs of the foundry.

In the operation of blast furnaces many factors combine to enhance the difficulty of ensuring a regular composition in the molten metal. Irregularities in the composition of the ore, flux and fuel in the burden; irregularities in the working of the furnace; uneven settling of the burden in the furnace, are amongst the numerous causes which tend towards irregularity in the composition of the molten metal. The extreme limits of variation possible are from white iron on the one side to siliceous iron on the other side. Variations of these extreme limits between consecutive tappings rarely ever occur without sufficient warning to the experienced blast-furnace manager. Changes of a smaller magnitude are of a much more frequent occurrence, and it is necessary that some provision should be made to take care of these variations.

This difficulty is to some extent provided for by the use of a receiver ladle or a metal mixer arrangement into which the molten metal from the blast furnace can be retained against the demands for casting purposes. Consecutive "taps" of metal from the furnace are received in the same receptacle, and the admixture of these with the metal remaining from previous collection has the tendency to reduce the extent of the smaller variations in chemical composition. In this connection it is of importance to refer to the necessity for maintaining a correct appreciation of the limits of variation in composition allowable for general castings. The permissible limits of variation are in reality much wider than many people are prepared to admit when considering this subject in abstract. The variation in the daily composition of cupola-melted metal intended for general castings is often greater than the variations met with in daily blast-furnace practice. There are many foundries daily producing general castings differing widely in character, and using one mixture of iron only where text-book regulations would specify distinct variations in composition. The fact that practical success is obtained under these conditions is also practical evidence that comparatively large limits of variation in composition are permissible, to such an extent that it is impossible to maintain nationally the view that the difficulty of ensuring a reasonably consistent chemical composition in direct blast-furnace metal is a serious objection.

Incorporation of a Receiver Desirable.

The use of a metal mixer or receiver provides a means whereby the second organisation difficulty of providing and maintaining a supply of molten metal to meet the varying requirements of the foundry, can be surmounted. The use of a receiver of sufficient capacity provides a reservoir from which molten metal can be drawn as and when required. The question as to whether the receiver should take the form of a simple receiver ladle or should be supplied with heat from an external source depends very largely on the particular conditions under which it is required to operate and the character of the castings to be dealt with. In the large ingot mould foundries of America large receiver ladles of 80- to 100-ton capacity are used. These ladles are almost totally enclosed with the exception of the tapping or pouring spouts, and are used without any auxiliary heating devices. In the case of the production of thinner castings, such as spigot and socket pipes in smaller tonnages, it appears necessary to use smaller capacity receivers equipped with auxiliary heating devices. A 25-ton capacity receiver of a stationary type, fired by means of crude oil burners, has recently been described as being in use in a German pipe foundry. Oil firing has been generally adopted on the smaller types of metal receivers which have been constructed hitherto. In the large metal mixers used for storing molten blast-furnace metal for the steel processes gas firing is, of course, employed.

In view of the conditions under which the iron industry is at present operating, it is imperative that every possible means of lowering production costs should be taken advantage of. The more extended application of direct blast-furnace metal to the production of castings is a line of development holding out many possibilities, and there does not appear to be any serious objection which can be sustained against its use for this purpose. On full consideration, it would appear that the clauses in various specifications prohibiting the use of direct metal are in need of complete revision.

Iron and Steel Output in March.

The National Federation of Iron and Steel Manufacturers report that the number of furnaces in blast at the end of March was 178, a net increase of 12 since the beginning of the month. At the end of April last year, 147 furnaces furnaces were in blast, and 151 at the end of March, 1926. The production of pig-iron in March amounted to 671,800 tons, compared with 571,100 tons last February, 568,500 tons in March, 1926, and a monthly average of 669,500 tons in 1920. Last month's output included 229,800 tons of hematite, 221,400 tons of basic, 167,700 tons of foundry, and 21,200 tons of forge iron.

The production of steel ingots and castings in March amounted to 949,600 tons, compared with 826,800 tons last February, 784,100 tons in March, 1926, and a monthly average of 755,600 tons in 1920.

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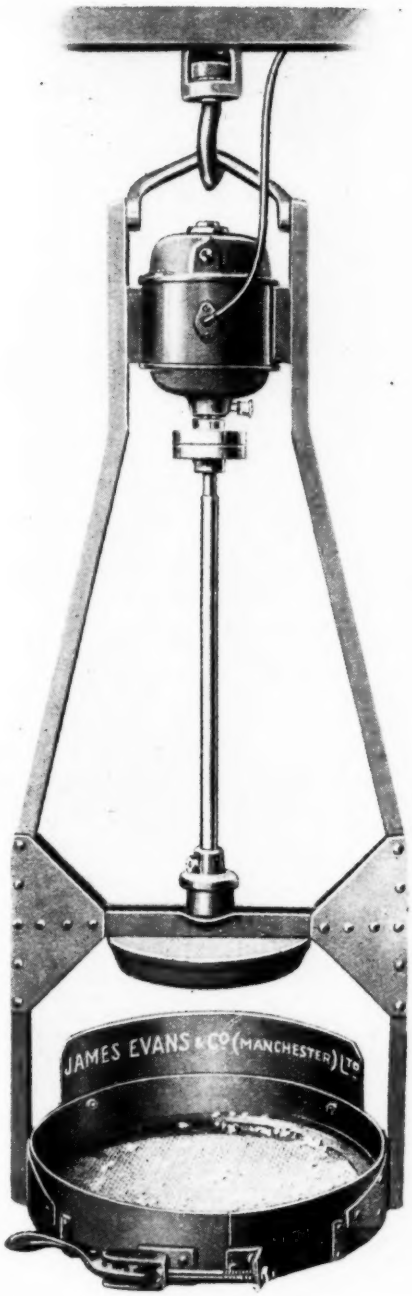

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BRITANNIA WORKS,

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Trade Talk.

A report is current that the constructional works of Sir William Arrol & Company, at the King's Dock, Swansea, may be acquired by A. D. Dawnay & Sons, constructional engineers, of Battersea and Cardiff.

The ascertained price of No. 3 G.M.B. Cleveland pig-iron for the first quarter of the year having been 78s. 2.31d. per ton, blastfurnacemen's wages as from the 3rd inst have been advanced by 9.25 per cent., bringing the wages from 14.75 per cent. above the standard to 24 per cent. above the standard.

At a conference of Cleveland ironstone mine-owners and miners' representatives, held at Middlesbrough on Monday, it was agreed that wages of the Cleveland miners and Weardale quarrymen be reduced by 5 per cent., the reduction to take effect from the 25th inst. With regard to an application from the mechanics at the Cleveland ironstone mines for an increase on their base rates, which request had been investigated by a joint sub-committee, it was agreed to grant an advance of 4d. per shift on certain rates. This advance takes effect as from Monday.

Mr. Mence Wilkinson, presiding at the meeting of the Central Provinces Manganese Ore Company, Limited, gave details of the United Kingdom Ferro-Manganese Company, Limited, with which the company is connected, and has a share capital of £350,000. The object of the company is the unification of interests between the ferro-makers and the Central Provinces as manganese ore producer. The new company is to buy from the ferro-manganese makers the whole of their production of ferro manganese at an arranged price and to sell it for the benefit of the ferro-manganese makers and the Central Provinces Company. That company had thus secured an outlet for a considerable portion of its production, and it had, to an important extent, consolidated its interests with a number of ferro-manganese makers who had taken supplies of the company's ore for many years past.

Personal.

The recent rumours to the effect that Mr. P. N. Rand, the general sales manager of the Metropolitan-Vickers Electrical Company, Limited, is severing his connection with that company are now confirmed. Mr. Rand will officially terminate his connection with the company on September 30 next, by which time he will have completed nearly 19 years' service with them. Mr. Rand will, however, relinquish his active representation about the middle of May, and hopes to travel abroad this summer for a few weeks before taking up new duties. In whatever direction those duties may lie we wish Mr. Rand, who is so well known to many of our readers, the greatest possible success. Mr. Rand's address from the middle of May onwards and until further notice will be c/o the Royal Automobile Club, Pall Mall, London, W.

On Wednesday, April 6, an interesting ceremony took place at the Butterley Company's Colliery Offices, Ironville, when a presentation was made to Mr. H. Eustace Mitton, J.P., the company's mining advisor, upon his election to a seat on the board of directors, in recognition of his services to the company. The presentation was made by Mr. John Holbrook, J.P., the company's chief surveyor, and their oldest official, and took the form of a gold cigarette case, in which was inscribed the signatures of the staff in facsimile. In making the presentation Mr. Holbrook referred to the long period the company had been established—137 years. On the formation of the company, their activities, he said, were solely concerned with the ironworks, the coal business being developed a few years later as an accessory to the iron business, and although the colliery department had assumed such an important position in the company's affairs, they did not presume to think they were superior to the ironworks, but at least were brought up to their level. It was, he said, 22 years since Mr. Mitton was appointed the chief of the colliery department, and this honour was a fitting reward for the energy and hard work which he had put in in the interests of the old company. In returning thanks Mr. Mitton said that in 1905, when he formed the company, the output was just one million tons per annum, and to-day they had three million tons, and also have a larger coal reserve than in 1905. Another achievement, he said, was the development of electric power, under the control of Mr. H. A. Jackson. Continuing, Mr. Mitton said he felt that the success lay in the fact that all had pulled together during this period.

Will.

Ellis, S. H., of 8, Eastmoor Road, Wakefield, late senior partner of Alfred Ellis & Sons, brassfounders £5,181

Contracts Open.

Alnwick, April 25.—1,365 yards of 3-in. and 3,798 yards of 4-in. cast-iron socket pipes, complete with fittings, and an open iron tank to hold 7,000 gallons, for the Rural District Council. The Clerk, 24, Fenkle Street, Alnwick.

Auckland, N.Z., June 7.—One 3-ton electric travelling jib crane, for the Auckland Harbour Board, New Zealand. Mr. C. R. Butters, the Board's London agent, 96, Charterhouse Chambers, London, E.C.1. (Fee £1 1s.)

Durban, May 13.—41 assorted sluice valves, for the Borough of Durban. The Department of Overseas Trade, 35, Old Queen Street, S.W.1. (Ref. A.X. 4,521.)

Durban, May 13.—Cast-iron pipes and specials (W. 105), for the Borough Authorities of Durban. The Department of Overseas Trade, 35, Old Queen Street, S.W.1. (Ref. A.X. 4,520.)

Durban, May 13.—Steel straight pipes and collars (W. 106), for the Borough Authorities of Durban. The Department of Overseas Trade, 35, Old Queen Street, S.W.1. (Ref. A.X. 4,519.)

London, E.C.1, April 29.—(8) Iron and steel; (18) bolts and nuts, screws, files, shovels, steam tubes, etc.; (19) small iron, brass, gunmetal and other castings; and (20) G.M. stopcocks, etc., for six and 12 months, commencing June 1, for the Metropolitan Water Board. The Chief Engineer, 173, Rosebery Avenue, E.C.1.

Lyttelton (New Zealand), July 20.—Four 5-ton electrically-operated portal cranes and 10 electrically-operated capstans, for the Lyttelton Harbour Board. The Department of Overseas Trade, 35, Old Queen Street, S.W.1. (Ref. A.X. 4,532.)

Southport, April 27.—700 tons of cast-iron spigot and socket pipes and specials, 15 in. in dia., for the Southport, Birkdale and West Lancashire Water Board. Mr. C. B. Ede, engineer and manager, 14, Portland Street, Southport.

Sydney, N.S.W., June 7.—(No. 211) Oil engine pumping plant, for the Water Conservation and Irrigation Commission, N.S.W. The Department of Overseas Trade, 35, Old Queen Street, S.W.1. (Ref. A.X. 4,545.)

Company Reports.

James Dunlop & Company, Limited.—Loss for 1926, £17,950; less brought in, £608; debit balance carry forward, £17,342.

Herbert Morris, Limited.—Ordinary dividend for half-year to January 31, 1927, 7½ per cent. per annum, less income-tax, at 4s. in £ (same).

Harland & Wolff, Limited.—Profit, £201,446; brought in, £135,469; available, £336,915; dividend on £4,000,000 of first preference shares for year; carried forward, £144,915.

Babcock & Wilcox, Limited.—Net profit, £716,576, brought forward, £188,774; total, £905,350; final distribution on the ordinary shares, 8 per cent., free of tax, making 13 per cent. for year, free of tax; reserve fund, £150,000; staff pension fund, £20,000; carry forward, £161,442.

Anderson-Grice Company, Limited.—Gross profit, £3,163; brought forward, £167; interest on loans, etc., £124; rent, etc., recovered, £7; total, £3,462; depreciation, £1,324; Imperial taxation, £181; dividends for year (less tax) on first preference shares, 5 per cent., £240; dividend on second preference shares, 6 per cent. per annum, £933; dividend on ordinary shares, 3d. per share, £330; carried forward, £452.

New Companies.

J. H. Anderton & Son, Limited, 46, Manchester Road, Haslingden, Rossendale, Lancs.—Capital £1,000 in £1 shares. Ironfounders. Directors: J. H. Anderton and J. B. Anderton.

H. Barnett, Limited.—Capital £9,000 (£1). To acquire business of metal merchant carried on by H. Barnett, 2, Victor Road, Holloway, as H. Barnett.

E. J. Myerscough (Metals), Limited.—Capital £1,500. Metal scrap merchants, carried on at 6, Vine Street, Bury New Road, Higher Broughton, Manchester. Directors: Eliza J. Myerscough and H. Forster.

"Purali," Limited.—Capital £1,000. Aluminium, iron, steel, brass and general metal founders, etc. Directors: R. H. Pontet and A. Greensmith, 41, Loampit Hill, Lewisham, S.E.13.

Wear Winch & Foundry Company, Limited, Park Lane, Sunderland.—Capital £10 000 in £1 shares. To acquire business carried on at Sunderland by H. C. Coatsworth as Wear Winch & Reel Company. Directors: H. Jennings (managing director) and others.

No. of Alloy	Specific Gravity.	Melting Point °C.	Test Specimen.	Average Tensile strength Tons—sq. in.	Average Elastic limit Tons—sq. in.	Per cent. Elongation on 2 in.	Remarks.
4	2.75	643	Sand cast Chill cast	6.5 9.5	4.5 5.0	4 8–11	A light copper alloy which is an admirable substitute for soft brass. Is very ductile, and has a high shock resistance.
6	2.98	615	Sand cast Chill cast	13.0 13.5	8.5 9.0	4 5	A copper-zinc alloy which is very strong, easily cast and suitable for general purposes. It has excellent machining qualities.
6a	3.12	600	Sand cast Chill cast	16.0 17.5	12.0 11.0	2 5	Stronger, but heavier than No. 6. Will take a very high polish.
12	2.83	629	Sand cast Chill cast	7.0 10.5	6.0 7.0	2 4	A very reliable non-porous copper alloy. Is largely used for die-castings, as well as for sand castings.
38	2.88	622	Sand cast Chill cast	9.5 11.5	6.0 5.5	5	
50b	2.72	645	Chill cast	9.0	6.5	13	A light nickel alloy which makes hard ductile castings, suitable for mathematical instruments, etc.

The above figures are average test results made on specimens cast to 1 in. diameter and machined at the centre to 0.564 in. diameter.

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IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—Owing to the holiday interruption business in the Cleveland iron market is, as usual, practically suspended for a fortnight, and may in the meantime be best described as without change of importance. Hence, until conditions assume a more settled aspect, business will continue to be of a hand-to-mouth character, and consumers will resort in an increasing degree to Continental sources of supply. Quotations are unchanged as follow:—No. 1, 82s. 6d.; No. 3 G.M.B., 80s.; No. 4 foundry, 79s.; No. 4 forge, 78s. 6d. per ton.

There is no favourable development reported in the hematite trade. Business is very scanty, and quotations again show a weaker tendency. East Coast mixed numbers can now be done at 83s. per ton, which brings the margin between hematite and Cleveland No. 3 well below the normal. On the North-West Coast conditions are somewhat similar to those recorded above, Bessemer mixed numbers being quoted at £4 14s. 6d. per ton delivered at Glasgow, £4 15s. 6d. per ton delivered at Sheffield, and £5 1s. 6d. per ton delivered at Birmingham.

LANCASHIRE.—In this area consumers are also holding off the market, and so far as Derbyshire iron is concerned quotations are weak at 89s. to 90s. per ton, delivered into this area. Staffordshire makers have not so far revised their rates, and 90s. per ton delivered is still the figure quoted here. Weakness is apparent in Scottish brands, about 103s. per ton, delivered Manchester or equal, being the more usual price mentioned on this market.

THE MIDLANDS.—Supplies of foundry pig-iron in the local markets are plentifully available at easier rates. No. 3 Northamptonshire pig is now on offer between 78s. and 79s. 6d., No. 3 Derbyshire and Staffordshire from 81s. to 82s. 6d. per ton, all f.o.t. furnaces. Cleveland No. 3 price is 95s., and Lincolnshire 92s. 6d., delivered this area.

SCOTLAND.—There is no change to report in the state of the Scottish pig-iron market, and prices continue easy on the basis of 85s. for No. 3 foundry at the furnaces, and with the continued fall buyers are holding back and buying as sparingly as they can.

Finished Iron.

Activity in the various manufacturing branches of the finished iron trade is still restricted by the continued high cost of production, but Midland makers of marked bars remain fairly well occupied, and have no difficulty in securing the standing figure of £14 10s. at works. With regard to crown bars, however, the prices are cut considerably, and it is difficult to name a definite price; so much depends upon the nature of the specification; £11 is being quoted in a number of directions, and the price varies from this up to £11 15s. per ton. Lancashire makers are competing with the Staffordshire works, and are taking the lowest prices. There is little business being given out for nut and bolt and fencing iron, either locally or to the Continental mills, although the latter procure by far the greater portion of what business there is being placed, solely on account of the price.

Scrap.

For obvious reasons markets for scrap metal continue quiet, and in Scotland heavy machinery cast-iron scrap is again rather difficult to dispose of, and the best price being paid is now around 80s. to 81s. 3d. per ton, that is for material suitable for foundries, and in pieces not exceeding 1 cwt. Heavy ordinary cast-iron scrap to the same specification is 5s. per ton less, and for steelworks cast-iron scrap to their sizes 70s. to 72s. 6d. per ton. Light cast-iron scrap and firebars is 58s. 6d. per ton, with little or no business doing. The above prices are all per ton, delivered f.o.t. consumers' works.

Metals.

Copper.—A weaker tendency in values of standard copper has developed recently, due largely to the disturbing events in China and increasing offers on forward account. The weakness has latterly been accentuated on account of lower advices from America, where offers were made to domestic consumers at lower prices, and terms for export f.a.s. were reduced. Under the subsequent sagging tendency of prices, trade demand generally drooped, and second-hand offers of electrolytic in this market became more prominent.

Official closing prices of standard copper have been as follow:—

Cash: Thursday, £55 5s. to £55 6s. 3d.; Tuesday, £55 15s. to £55 16s. 3d.; Wednesday, £55 10s. to £55 12s. 6d.

Three Months: Thursday, £55 17s. 6d. to £55 18s. 9d.; Tuesday, £56 5s. to £56 6s. 3d.; Wednesday, £56 2s. 6d. to £56 3s. 9d.

Tin.—Developments in standard cash tin have been erratic, but mostly downward, with not a great deal of trade buying, although America again placed orders for fair quantities of tin afloat and for direct shipment from Malaya. Prices have been distinctly weaker on the whole, but recovered most of the lost ground at one time with forward metal.

The Straits shipments for March were fully up to expectations. Deliveries in America were not quite so good as anticipated, and the U.K. outgoings were better, which, with the Continental takings, made an aggregate of 9,891 tons.

Official closing prices of standard tin have been as under:—

Cash: Thursday, £305 5s. to £305 10s.; Tuesday, £306 to £306 5s.; Wednesday, £302 5s. to £302 10s.

Three Months: Thursday, £298 10s. to £298 15s.; Tuesday, £299 10s. to £299 15s.; Wednesday, £297 5s. to £297 10s.

Spelter.—The market for ordinary spelter is unsettled, but the current price seems reasonable enough, and consumers are by no means fully covered, while Continental smelters do not seem keen sellers, although credited with nursing some accumulations.

The following are the week's prices:—

Ordinary: Thursday, £29 17s. 6d.; Tuesday, £30 2s. 6d.; Wednesday, £29 17s. 6d.

Lead.—While the soft foreign pig market is undoubtedly affected by the supplies of metal that continue to arrive, it is obvious that the situation is not really dominated by this, as values, while not actually advancing, show considerable resistance to bear tactics. Consumption is on a moderately satisfactory scale, and consumers purchase easily their requirements for early delivery from day to day.

The week's prices are appended:—

Soft foreign (prompt): Thursday, £27 6s. 3d.; Tuesday, £26 17s. 6d.; Wednesday, £26 15s.

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